MAR 24 1924

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXVII.—No. 3036.] *LONDON: FRIDAY, MARCH 7, 1924.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 3½d.

Aveling & Porter, Ltd.,
ROCHESTER.

Steam & Crude Oil Rollers.
SPECIAL ROLLERS FOR BITUMINOUS ROADS. 1869

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CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See advertisement page 18.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON E.C.2.
See half-page Advert. last week and next week. 1382

CRANES. All Types.
GEORGE RUSSELL & CO., LTD., Motherwell. 1867

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 1241
See Advertisement last week, page 19.

Spencer-Hopwood & Kirke
PATENT BOILERS 1293
See Page 73.
Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 1864

P. & W. MacLellan, Ltd.,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, Glasgow. Od 8547
Registered Offices: Clutha House, 10, Princes St., Westminster, S.W.1.

Brett's Patent Lifter Co.
LIMITED.
Hammers, Presses, Furnaces,
COVENTRY. 610

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works,
Manchester. Od 9753

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E. 15. 1794

Fuller, Horsey, Sons & Cassell.
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY
and
ENGINEERING WORKS.
11, BILLITER SQUARE, E.C.3. 1834

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement, page 75, Feb. 29.

YARROW & CO. (1922), LTD., GLASGOW.
PASSENGER AND CARGO STEAMERS.
SHALLOW DRAFT VESSELS. 1562

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 12 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
Spur Wheels cut up to 9 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

VOSPER & CO., LTD.,
PORTSMOUTH,
SHIP & LAUNCH BUILDERS, Od 3551
ENGINEERS & BOILER MAKERS.

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS.
PRESSED STEEL WORK OF ALL KINDS.
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OIL FUEL APPLIANCES,
Systems
PRESSURE, AIR, STEAM
For Boilers of all types.
KERMODES LIMITED,
35, The Temple, Dale Street, Liverpool.
Naval Outfits a Speciality,
also for Merchants Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
Supplied to the British and other Governments.
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Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Od 3457
See their Illus. Advertisement, page 89, last week.

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS,
MOTHERWELL. Od 3383

R. Y. Pickering & Co., Ltd.
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BUILDERS of RAILWAY CARRIAGES & WAGONS
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
WISHAW, near GLASGOW.
London Office: Od 8353
3, VICTORIA STREET, WESTMINSTER, S.W.

Patents and Trademarks:—
Inventors Advice, Handbook and Consultations free.—KINGS PATENT AGENCY, LTD. (P. T. King, Director), 146a, Queen Victoria Street, London. 36 years' refs. 1209

Rosser and Russell, Ltd.,
MECHANICAL ENGINEERS,
QUEEN'S WHARF, HAMMERSMITH, W.
Undertake SPECIAL MACHINE WORK of any description.
WELL EQUIPPED SHOP.
LATHE WORK up to 10 ft. diameter.
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London Office: 101, LEADENHALL ST., E.C.3.
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Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
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Combined Circulating and Air Pumps.
Auxiliary Surface Condensers,
&c., &c. 1586

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MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

IRON & STEEL
Tubes AND Fittings
AND
Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW BIRMINGHAM - LONDON.
See Advertisement, page 88. 1872

Peter Brotherhood Ltd.,
PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 1475
See Advertisement, page 53, Feb. 29.

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1948

For Sale, Motor Generator, by
Lancashire Dynamo Co. Ltd, 1920, Comprising, 480 volt, D.C. Motor, coupled to 105 volt, 820 ampere compound interpole Generator, complete with Switchboard.
THE PHŒNIX ELECTRICAL CO., LTD., 17, Oswald Street, Glasgow. C 475

For Sale
THREE No. 42-TON
STEAM TRAVELLING GOLIATH CRANES
by Ransomes and Rapier, Ltd.
100 ft. 1½ in. span.
Clearance 31 ft.
Travelling Speed 60 ft. per minute.
Traversing Speed 50 ft. per minute.
Hoisting Speed, full load, 10 ft. per minute.
Engines: Two Cylinders, 11½ in. diameter by 12 in. stroke.
Boilers: Vertical 11 ft. 1 in. by 5 ft. 3½ in. diameter.
Approximate weight 230 tons each.
For full particulars apply:—
Messrs. S. PEARSON & SON
(Contracting Department) Limited,
10, Victoria Street,
Westminster,
S.W.1. D 55

Gearing of all Descriptions.
GEAR WHEELS up to 10 ft. diameter.
FLY ROPE and SPUR DRIVING WHEELS up to 25 ft. diameter
BRICK and CLAYWORKING MACHINERY of all kinds.
ENGINES:—"Uniflow," "Corliss," or Drop Valve.
CLAYTON, GOODFELLOW & CO., LTD., Blackburn. 1249

Metallography with the Super-microscope. Paper read by Dr. Rogers, November 13th, before the Sheffield Metallurgical Society. See page 84.—F. DAVIDSON & CO., 29, Great Portland St., London, W.1. 2009

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS,
CONDENSERS, AIR HEATERS,
ROW'S PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5726

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS. 1563

Matthew Paul & Co., Ltd.,
LEVENFORD WORKS, Dumbarton. 1483
See Full Page Advt., page 61, Feb. 29.

Forgings.
Walter Somers, Limited,
HALESOWEN 7116

Taylor & Challen Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works, and Showrooms: BIRMINGHAM.
See advert., page 10, Feb. 29. 8105

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS.
Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 2033
E. GREENWICH, LONDON, S.E. 10 (& at Birmingham)

Railway Switches and Crossings
T. SUMMERSON & SONS, LIMITED,
DARLINGTON. 2006

DAVID BROWN & SONS (Hudd.) Ltd.
Lockwood Huddersfield.
HIGH CLASS
Machine Cut Gearing
FOR EVERY PURPOSE. 1440

HEAT INSULATION.
CELITE PRODUCTS CORPORATION,
Windsor House, Westminster, S.W.1. 1676
See our Illustrated Advertisement, Feb. 8.

Telegrams: "Epa," London.
Telephone: 7424 Central.
E. P. Alexander & Son.
CHARTERED PATENT AGENTS,
306, High Holborn, London, W.C. 1. 585
PATENTS. DESIGNS. TRADE MARKS.

James D. Roots—Patents,
BRITISH and FOREIGN. Moderate charges. Long and varied practical Engineering experience valuable to Inventors. Formerly many years contributor of Patents Abstracts for "The Engineer" & "The Times."—Thanet House, Temple Bar, London, W.C.2.

For Your Repairs or any
SPECIAL MACHINERY, try
THOMAS HUNT & SONS,
Albion Ironworks,
Bridge Road West, Battersea, S.W. 11.
Est. 1854. 2007

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
1676
See half-page Advertisement, page 65, Feb. 15.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by Sir WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction 2005

University of London.—A

Course of Lectures on "PRACTICAL HYDRAULIC ENGINEERING PROBLEMS IN CONNECTION WITH NAVIGATION" is being given by Mr. O. C. A. VAN LIDTH DE JEUDE, C.E. (Technical Managing Director of the Netherlands Harbour Works Co.), at the INSTITUTION of CIVIL ENGINEERS (Great George Street, Westminster, S.W. 1). The remaining Lectures on HARBOUR ENGINEERING ABROAD: SHIPPING CONDITIONS IN PORT; and the ZUIDERZEE SCHEME will be given on MARCH 17th, 19th and 21st, at Five p.m. The Lectures will be delivered in English and illustrated with lantern slides. ADMISSION FREE, WITHOUT TICKET.

EDWIN DELLER,
Academic Registrar. D 115

Correspondence Courses for

Inst.Civil Engrs., Inst.Mech.E., London Univ. (Matric., inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1993

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 1679

TENDERS.

The Director - General,

India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES:—

MOTOR DRIVEN AIR COMPRESSOR.

Tenders due on the 28th March, 1924.

Tender Forms obtainable from above. D 128

COUNTY BOROUGH OF MIDDLESBROUGH.

DOCKS, etc., SCHEME.

The Corporation invite

Tenders for the Construction

of DOCKS, WHARVES, LANDING PLACE, etc., at the site of the Ferry, Middlesbrough.

Copies of Conditions, Specification, and Form of Tender will be supplied on application to the undersigned on payment of a deposit of Five Pounds which will be returned on receipt of a *bona fide* Tender. The plans may be inspected at the Office of Mr. A. C. MITCHELL, M.Inst.C.E., Royal Exchange, Middlesbrough, where arrangements may also be made for loan of prints.

Sealed Tenders, on the Forms and in the envelopes supplied, are to be delivered to the undersigned on or before first post on Monday, the 24th day of March next, and endorsed "Tender for Docks Scheme."

The Council do not bind themselves to accept the lowest or any Tender.

The Scheme will be carried out as work for the relief of unemployment, and the Unemployment Grants Committee's conditions of grant will have to be complied with, which are fully set out in the General Conditions.

PRESTON KITCHEN,
Town Clerk.

Municipal Buildings,
Middlesbrough.
25th February, 1924. D 46

METROPOLITAN WATER BOARD.

TENDERS FOR THE MANUFACTURE, DELIVERY AND FIXING OF TWO 25 KILOWATT STEAM DRIVEN ELECTRIC GENERATORS, SWITCHBOARD, PIPING, ETC., AT LITTLETON PUMPING STATION, MIDDLESEX, AND ALSO FOR ONE 150 KILOWATT STEAM DRIVEN ELECTRIC GENERATOR, SWITCHBOARD, PIPING, ETC., AT WALTON PUMPING STATION, SURREY.

The Metropolitan Water Board invite

Tenders for the Manufacture,

DELIVERY AND FIXING OF TWO 25 KILOWATT STEAM DRIVEN ELECTRIC GENERATORS, SWITCHBOARD, PIPING, ETC., AT THEIR LITTLETON PUMPING STATION, MIDDLESEX, and also for ONE 150 KILOWATT STEAM DRIVEN ELECTRIC GENERATOR, SWITCHBOARD, PIPING, ETC., AT THEIR WALTON PUMPING STATION, SURREY.

Forms of Tender, Conditions of Contract, Specification and Drawings may be inspected without payment of fee at the Offices of the Board (Room 173) Chief Engineer's Department, 173, Rosebery Avenue, Clerkenwell, E.C. 1., on and after Monday, 10th March, 1924.

Contractors desirous of Tendering may obtain the necessary documents from Mr. HENRY R. STILGOE, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of One Guinea *for either set of documents*, which sums must be deposited with the Board's Accountant, and will be returned on receipt of *bona fide* Tenders, together with all incidental papers. Such payments and applications must be made between the hours of Ten a.m. and 4.30 p.m. (Saturdays Ten a.m. and Twelve Noon). Cheques must be made payable to the "Metropolitan Water Board," and not to individuals.

Tenders enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, E.C. 1" and respectively endorsed "Tender for Electrical Plant, Littleton" and "Tender for Electrical Plant, Walton," must be delivered at the Offices of the Board not later than Ten a.m. on Wednesday, 23rd April, 1924.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173 Rosebery Avenue, E.C.1.
29th February, 1924. D 104

STATE ELECTRICITY COMMISSION OF VICTORIA.

Melbourne,
VICTORIA,
AUSTRALIA.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available upon application to:—

AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C.2.

SPECIFICATION No. 24/7.

100,000 VOLT TESTING TRANSFORMER.

CHARGE:—10/- for the first two copies of Tender Form, Conditions of Contract and specification complete. This charge will be returned on receipt of a *bona fide* Tender. A third copy and any further copies will be supplied for the sum of 5/- each. This charge is not returnable.

PRELIMINARY DEPOSIT:—A Preliminary Deposit of £5 is to be lodged with Tender.

The Specifications may be inspected at the above-mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders close at the Commission's office, Melbourne, on the 10th March, 1924, and prices should be cabled (cable address, "Electrocom, Melbourne") to the Commission on or before that date, and Tenders on the prescribed form, properly endorsed and addressed, must be forwarded by the following mail to:—

E. LIDDELOW,
Secretary.

State Electricity Commission of Victoria,
Melbourne, Victoria, Australia. C 943

TYNE IMPROVEMENT COMMISSION.

DREDGING PLANT.

The TYNE IMPROVEMENT COMMISSIONERS are prepared to receive

Tenders for the Construction

and DELIVERY in the Tyne of TWO SINGLE SCREW STEEL, STEAM HOPPER BARGES, each with a hopper capacity of about one thousand tons.

Copies of the Form of Tender, Conditions of Contract, Specification and Outline Drawing may be obtained from this Office on payment of a deposit of £1 2s. which will be returned on receipt of a *bona fide* Tender.

Tenders in sealed envelopes, endorsed "Tender for Hopper Barges" must be delivered at the undermentioned Offices, addressed "The Chairman, Dredging & River Works Committee," not later than Noon on Tuesday, the 1st day of April, 1924.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
ALBERT BLACKLOCK,
Secretary.

Tyne Improvement Commission Offices,
Hewick Street,
Newcastle-upon-Tyne.
5th March, 1924. D 118

BOROUGH OF DURBAN, NATAL.

SHONGWENI WATER SCHEME.
VERNON HOOPER DAM.

TENDER FOR LARGE SLUICE VALVES, VALVE TOWER IRONWORK, PIPES, ETC.

The Corporation of Durban invite

Tenders for the Supply and

DELIVERY of the following:—

1. 15 Large Needle Valves or Torpedo Sluice with operating gear, and Steel or C.I. Lining for Sluiceways with appurtenant Ironwork.
2. Travelling Crane, Cut-off Spheres, Trucks, Screens, Standpipes, etc.
3. Cast Iron Pipes, Valves, Venturi Meter for Sphere Pumps, and Cast Iron special pipes, etc., in accordance with drawings and specifications prepared by MR. WALTER M. CAMPBELL, M.INST.C.E., M.I.MECH.E. BOROUGH WATER ENGINEER, DURBAN.

Copies of the Specification, Drawings and Form of Tender may be obtained from Messrs. WEBSTER, STEEL & Co., 5, East India Avenue, London, E.C., upon payment of a deposit of Five Guineas, returnable only after a *bona fide* Tender has been received and duly considered.

Sealed Tenders, addressed to the TOWN CLERK, Durban, marked outside "Tender for Sluice Valves, etc., Vernon Hooper Dam," will be received at the Town Clerk's Office, Durban, until Eleven a.m., on Friday, 2nd May, 1924. D 127

GREAT NORTHERN RAILWAY (IRELAND).

SECOND-HAND MACHINERY FOR SALE.

The Directors are prepared to receive

Tenders for the Purchase

of the following SECOND-HAND MACHINERY:—

One Portable Engine		Brown & May, Single Cylinder, 10 in. diameter by 16 in. stroke.
One	"	Garrett & Sons, Single Cylinder, 7 in. diameter by 12 in. stroke.
One	"	Robertson & Auden, Single Cylinder, 7 in. diameter by 12 in. stroke.
One Traction Engine		J. Fowler & Sons, nominal H.P. 8 to 10.
One Upright Log Saw		(self contained) Steam or Belt Driven, Cylinders 12 in. by 24 in., to take logs up to 36 in. square or diameter. Makers—Thomas Robinson & Sons.

The Log Saw can be seen on application to the Company's Locomotive Engineer, Dundalk, and the Engines on application to the District Engineer, Dundalk.

Tenders made out on forms supplied by the Company should be delivered, under sealed cover endorsed "Tender for Machinery," to the undersigned, not later than Ten a.m. on 26th March, 1924.

The Directors do not bind themselves to accept the highest or any Tender.

J. B. STEPHENS,
Secretary.

Amiens Street Station,
Dublin, 27th February, 1924. D 92

GREAT NORTHERN RAILWAY (IRELAND).

TENDERS FOR SLEEPERS.

The Directors are prepared to receive

Tenders for Supply of Baltic

REDWOOD SLEEPERS, 9 ft. by 10 in. by 5 in. Tenders, made out on the Forms supplied by the Company, should be delivered, under sealed cover, endorsed "TENDER FOR SLEEPERS," to the undersigned, not later than Ten a.m., on Monday, 31st March, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

J. B. STEPHENS,
Secretary.

Amiens Street Station.
Dublin, 4th March, 1924. D 123

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon, on Friday, 21st March.

Tenders for the Supply of

WHITE LEAD.

Tenders must be made on Forms, copies of which, with Specification, can be obtained at these Offices on payment of 10s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices: 91, Petty France,
Westminster, S.W. 1.
5th March, 1924. D 126

DREDGER.

THE LEE CONSERVANCY BOARD invite

Tenders, Designs and

Specifications for a STEAM LADDER BUCKET DREDGER, 80 feet long by 13 feet Beam, depth middle line 4 ft. 6 ins. draught not to exceed 3 feet, to dredge to a depth of 12 feet and raise not less than 65 tons per hour, to load into barges 4 ft. 6 ins. above water-line and to be forward cutting to cut its own floatation. The framing and gear to be easily lowered so as to pass under bridges 6 ft. 9 ins. above water-line. The hull to be of Steel to Lloyd's Specification, with accommodation for two men to sleep on board. State time of delivery afloat ready for work on the Lee Navigation at Bromley Lock, Bow, London, E.

The Board do not bind themselves to accept the lowest or any Tender, and all designs offered are to be at the expense of the persons tendering. Tenders, Designs and Specifications, giving full particulars, to be delivered in sealed envelopes, marked "Dredger," not later than March 26th, 1924, to:—

CHARLES N. TWEEN, M.Inst.C.E.,
Engineer and Manager to the Board,
Enfield Lock, Middlesex D 133

GREAT NORTHERN RAILWAY (IRELAND).

The Directors are prepared to receive

Tenders for the Supply of:—

ONE 40-TON WELL WAGON,

in accordance with the Drawings and Specification, copies of which can be obtained on application to the undersigned, on payment of £1, which will be refunded on receipt of a *bona fide* Tender, and on return of the Drawings and Specification.

Tenders, made out on the forms supplied by the Company should be delivered, under sealed cover, endorsed "TENDER FOR WELL WAGON," not later than Ten a.m., on 27th March, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

J. B. STEPHENS,
Secretary.

Amiens Street Station,
Dublin, 29th February, 1924. D 93

GREAT NORTHERN RAILWAY (IRELAND).

TO BRIDGE CONTRACTORS.

The Directors are prepared to receive

Tenders for the Reconstruction

and ERECTION of a STEEL UNDERLINE BRIDGE, and CYLINDERS, between Newbliss and Clones.

The Drawing and Specification may be inspected at the Engineer's Offices, Dublin and Belfast, and copies of same, together with Bills of Quantities and Forms of Tender, may be obtained from the undersigned on payment of two guineas, which will be refunded on receipt of a *bona fide* Tender and return of the Drawings.

Tenders, made out on the Forms supplied by the Company, should be delivered under sealed cover, endorsed "TENDER FOR BRIDGE," not later than Ten a.m. on Saturday, 22nd March, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

J. B. STEPHENS,
Secretary.

Amiens Street Station,
Dublin, 4th March, 1924. D 121

COUNTY BOROUGH OF WOLVERHAMPTON.

WATERWORKS UNDERTAKING.

15 in & 12 in. CAST IRON TRUNK MAINS.

The Wolverhampton Corporation is prepared to receive

Tenders for Providing and

LAYING about 5400 yards of 15 in. and 2950 yards of 12 in. CAST IRON WATER MAINS, and executing other work in connection therewith, from Contractors who pay to the whole of their employees such remuneration and observe such hours of employment as are recognised by the Employees' Unions and Associations of Employers in the several localities where the work is done.

A copy of the specification, quantities, and form of Tender may be obtained from Mr. H. A. B. WOODWARD, Waterworks Engineer, Town Hall, Wolverhampton, upon payment of the sum of £2 sterling, which amount will be returned to each Contractor who submits a *bona fide* Tender, but not otherwise.

Each Tender must be enclosed in a sealed envelope, addressed to "The Chairman of the Water Committee," and endorsed "Trunk Mains," and delivered at my Office on or before Ten a.m., on Saturday, the 15th day of March.

The right to decline the lowest or any Tender is reserved to the Corporation.

F. H. WARBRECK HOWELL,
Town Clerk.

Town Hall, Wolverhampton,
5th March, 1924. D 134

APPOINTMENTS OPEN.

The University of Oxford will

shortly proceed to APPOINT a DIRECTOR of the INSTITUTE for Research in Agricultural Engineering at a salary of £800.

Forms of application may be obtained from the SECRETARY to the Committee for Rural Economy, by whom applications will be received till March 15. C 903

Wanted, a Thoroughly Com-

petent Theoretical PHYSICIST. Must be capable of independent research, a brilliant mathematician, and should know German. Excellent prospects for the right man. State age, experience and salary required, in confidence.—Address, D 108, Offices of ENGINEERING.

Chief Estimator Required by

Gas Constructional and General Engineers in Midland Counties, to take charge of Sales Department. State qualifications, salary required, and when at liberty. All applications treated in confidence.—Address, D 116, Offices of ENGINEERING.

Works Manager—Assistant

or Understudy, Box No. C. 982. Advertisers desire to generally acknowledge and thank applicants for their replies. These are being dealt with as quickly as individual scrutiny of the very large number will permit. Some little time must elapse before even selections for interview can be made. D 109

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Secretary of Education.

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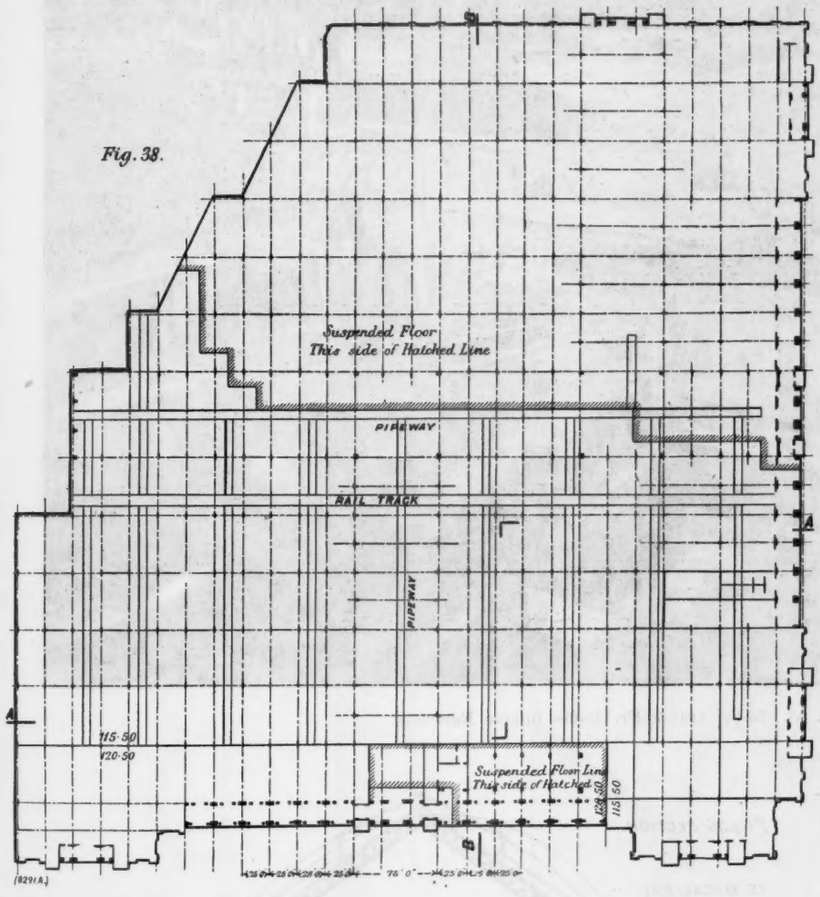
THE BRITISH EMPIRE EXHIBITION BUILDINGS.

(*Concluded from page* 266.)

THE Palace of Industry, although not quite so large as the Palace of Engineering, yet covers an area of nearly 10 acres and is certainly one of the largest ferro-concrete structures in the world. A ground plan of the building is given in Fig. 38 subjoined, while cross-sections are given in Figs. 41 and 42 on Plate XXI. These two latter figures, in conjunction with Fig. 46 on Plate XXII, will give a good general idea of the interior. As will be seen, there are two 75 ft. aisles crossing at right angles and forming the main internal feature of the building. The other aisles are all 50 ft. wide. In both cases a roof structure has been designed which requires no internal ties and the final effect is very striking as will be clear from Fig. 46. Both types of roof are of great interest, and the absence of internal ties or other obstructions gives a remarkably clear and graceful effect. Both of these types of roof are used in the Palace of Engineering, but the very striking form shown in Fig. 46 only to a very limited extent, and the absence of any necessity for providing overhead crane service in the Palace of Industry has allowed of this effective construction being employed for the main aisles.

Fig. 38.



The structure, as in the case of the Palace of Engineering, is built on partially levelled ground. The general arrangements in connection with this levelling we referred to in our last issue, but we may here repeat that complete levelling was not carried out on the score of cost. As it is, the local levelling of the ground for the building threw it below the level of the east and west avenue to the north of the lake. This condition has been met, as in the case of the Palace of Engineering, by making the floor level of the bay next to the lake higher than the remaining part of the floor, as shown at the right-hand side of Fig. 41. Breaks are made in this higher level at the main entrance and a slope given to the footway so that no steps are required. As in the case of the engineering building, a large part of the area of the floor is carried on brick-piers, the area supported in this way being indicated by the hatched lines in Fig. 38. Details of the brick piers and of the reinforced floor are given in Figs. 39 and 40. This suspended floor has been designed for a super load of 1½ cwt. per square foot. A Foden wagon has been run over it, and it has been tested with a 6-ton point load in any position in relation to the brick piers. As will be seen from Figs. 41 and 42, sunk standard gauge railway lines have been carried through the 75 ft. aisles to facilitate the bringing in and removal of heavy exhibits.

Before dealing with some of the details of the structural parts of the building it will be well to refer to the general views given in Figs. 45 to 48 on Plates XXII and XXIII, as a brief consideration of these will enable the relation of the various detail parts to the whole to be more readily grasped. The position of the two main 75 ft. aisles is clearly indicated in the plan given in Fig. 38, and views of the point of intersection of these two aisles are given in Figs. 45 and 46, the former showing the aisles during the erection of the roof and the latter after completion. A view showing the shuttering for the main columns is given in Fig. 47. The 50 ft. bays, the arrangement of which will easily be followed from the plan Fig. 38, and the cross-sections given in Figs. 41 and 42, are all furnished with a type of roof carried by reinforced concrete principals of the form shown in Fig. 48. This view is actually that of two of the bays of the Palace of Engineering, but the arrangement in the Palace of Industry is exactly similar. An actual view showing some of the bays of this type in the Palace of Industry is given in Fig. 55 on page 292.

The east and south faces of the building fronting the main avenue and the lake have ornamental façades finished with cement-faced breeze blocks. The north and west faces are closed by brick screen walls. The façades are independent reinforced concrete structures and do not depend on the block structure for their support. A good idea of the structural features of these façades is given by Fig. 43 on Plate XXI, which shows one of the main entrances. The façade practically completed with the breeze block screen walls in place is shown in Fig. 44. As will at once be noted the centre columns carrying the entablature, look somewhat slight although actually they are of ample strength to carry their load. These columns are filled in below the capital with breeze blocks in the completed building, the blocks having been left out, as shown in Fig. 44, in order to give greater clearance around the railway track during the erection stages.

Fig. 39.

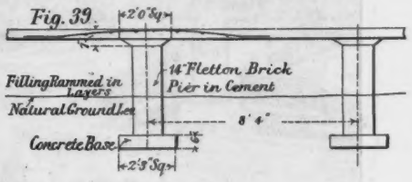
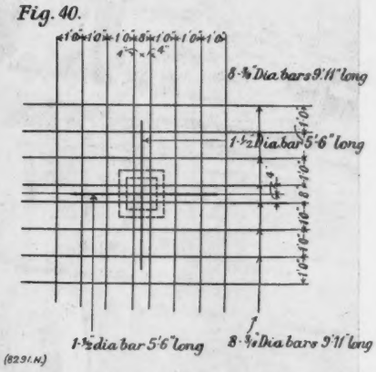


Fig. 40.



The complete roof of the 75 ft. bay is shown in Fig. 56, on page 292, while details of the steel-work are given in Figs. 49 to 54 on Plate XXIV. As seen from Fig. 56 in conjunction with Figs. 45 to 47, the steel construction is carried on cantilever arms of reinforced concrete which are cast *in situ* along with the columns. As the curve of the cantilever arm is carried on by the line of the steel rib, as best shown in Fig. 46, an unbroken sweep to the apex of the roof is obtained which is remarkably effective and indeed impressive. As will be clear from Fig. 47, the reinforced columns and cantilever arms together with the longitudinal beams connecting them were cast in position, shuttering being built to contain the whole structure. Considerable skill and care were necessary in the forming and building of this shuttering, as the springing points of the roof principals had to be accurately spaced and kept properly in line and at the correct height. The most difficult point of this construction was at the intersection of the two aisles shown in Figs. 45 and 46, where the corners of the reinforced concrete work had to be located accurately to take the lower ends of diagonal roof principals which form the intersection of the two aisle roofs, and at the same time proper alignment had to be kept with the columns and cantilevers of the two aisles.

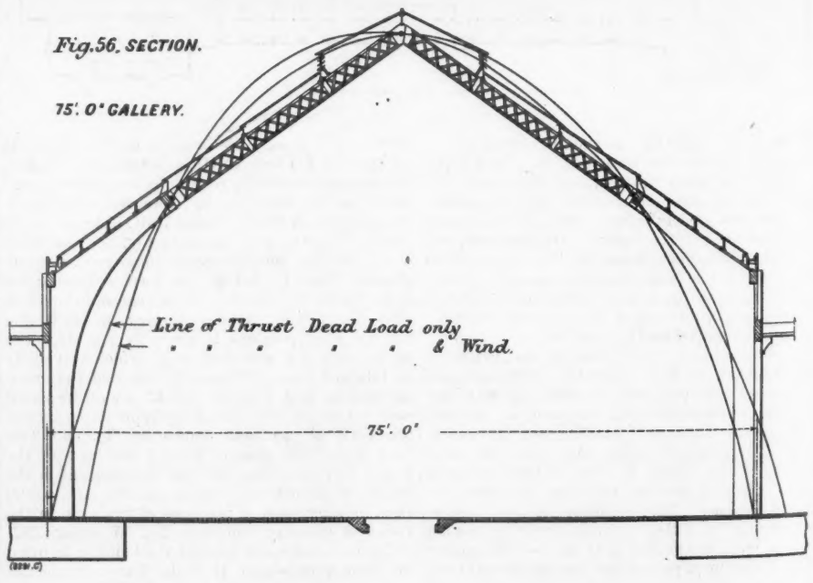
The steel work of this roof is of quite a simple nature, consisting of a pair of lattice ribs pin-connected at their lower ends and at the point of meeting at the apex. The positions of the line of thrust for dead load only and for dead load plus a wind pressure of 20 lbs. per square foot are indicated in Fig. 56. As will be seen, under any conditions the line of thrust lies well within the foundation blocks of the columns. It will be clear that the vertical distance from the line of thrust to the neutral axis gives the bending moment at any point of the structure. The detail construction of the three-hinge steel ribs will be followed from Fig. 49. As will be seen they are 1 ft. 9 in. deep, and

THE PALACE OF INDUSTRY; BRITISH EMPIRE EXHIBITION.

FIG. 55. 75-FT. AND 50-FT. AISLES DURING ERECTION.

are built up with two 3½ in. × 2½ in. × ⅜ in. steel angles to each flange, braced by 2½ in. × ⅜ in. flat-lattice bars with cast-iron distance pieces at the crossings. The hinge pins at each end are 1¾ in. diameter. The arrangement of these hinges is clearly shown in Figs. 49 and 54, and need not here be referred to in detail, the former figure shows the ribs used in the galleries, and the latter one of the four diagonal ribs which are used at the point of intersection of the two galleries. These diagonal ribs can clearly be seen in Figs. 45 and 46.

The centre portion of the roof is formed with ventilating louvres running the full length and is glazed with patent glazing carried out by Messrs. Mellowes and Co., Limited, of Sheffield. The lower portions of the roof are covered with Trafford asbestos cement tiles. A 12 in. × 5 in. rolled steel joist connects the hinged ribs at the apex of the principals, and two 10 in. × 4 in. channel longitudinals are also fixed to the hinged ribs to carry the glazing. These are secured by small seatings of ⅜ in. plate. The upper channel carries the louvre structure of which a side elevation is given in Fig. 50. At its lower end the glazing is carried by a timber construction of which details are given in the figures. The tiles are supported on a special type of light-pressed steel purlin, which is detailed in Fig. 53. These purlins rest on timber seatings on the reinforced concrete work, and are bolted down by four ⅝ in. bolts cast into the concrete. The various detail arrangements made in



THE PALACE OF INDUSTRY AT THE BRITISH EMPIRE EXHIBITION.

(*For Description, see Page* 291.)

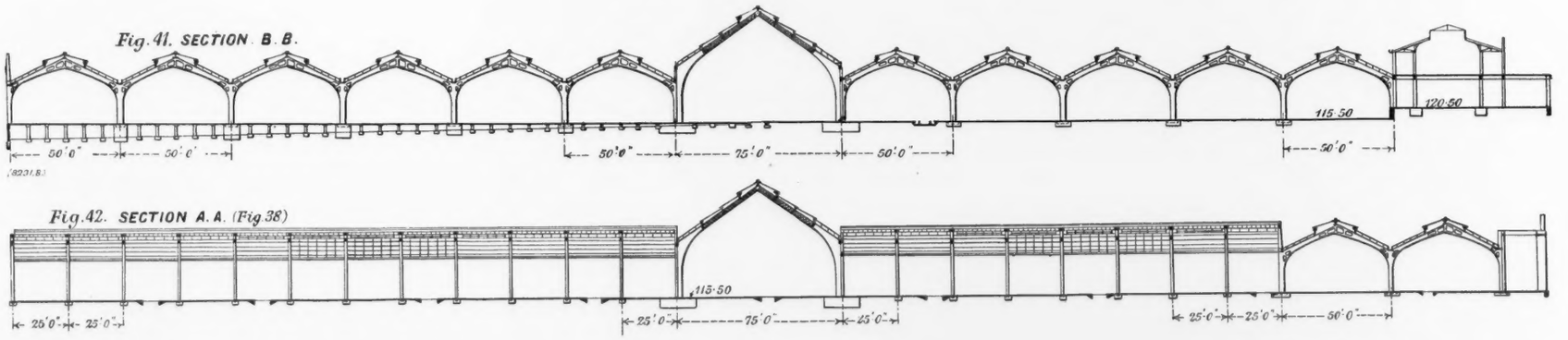


FIG. 43. FRAMEWORK OF MAIN ENTRANCE.

FIG. 44. MAIN ENTRANCE NEARLY COMPLETED.

THE PALACE OF INDUSTRY AT THE BRITISH EMPIRE EXHIBITION.

(*For Description, see Page* 291.)

Fig. 45. 75-Ft. Aisles During Erection.

Fig. 46. 75-Ft. Aisles Completed.

THE PALACE OF INDUSTRY AT THE BRITISH EMPIRE EXHIBITION.

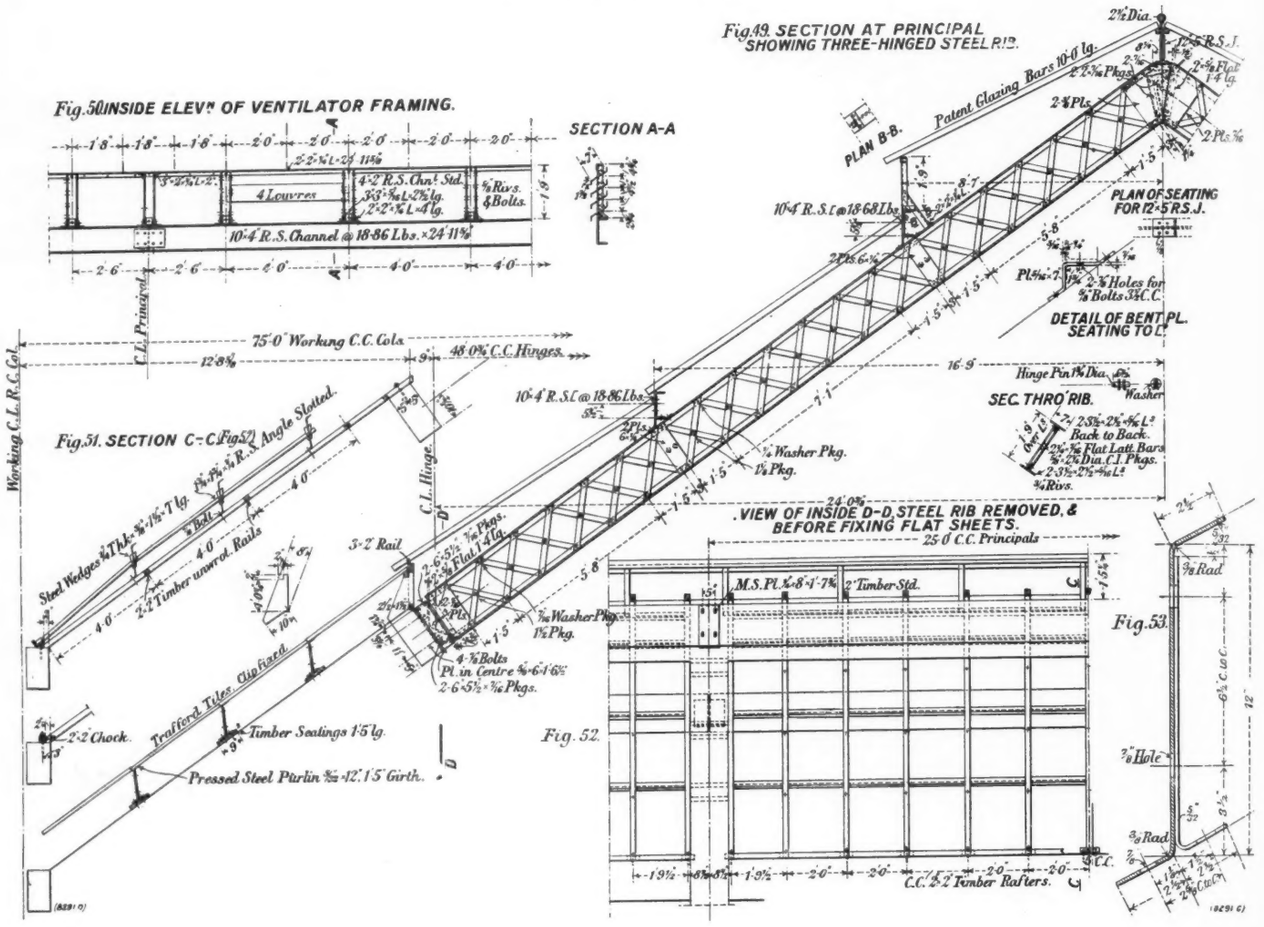
(*For Description, see Page* 291.)

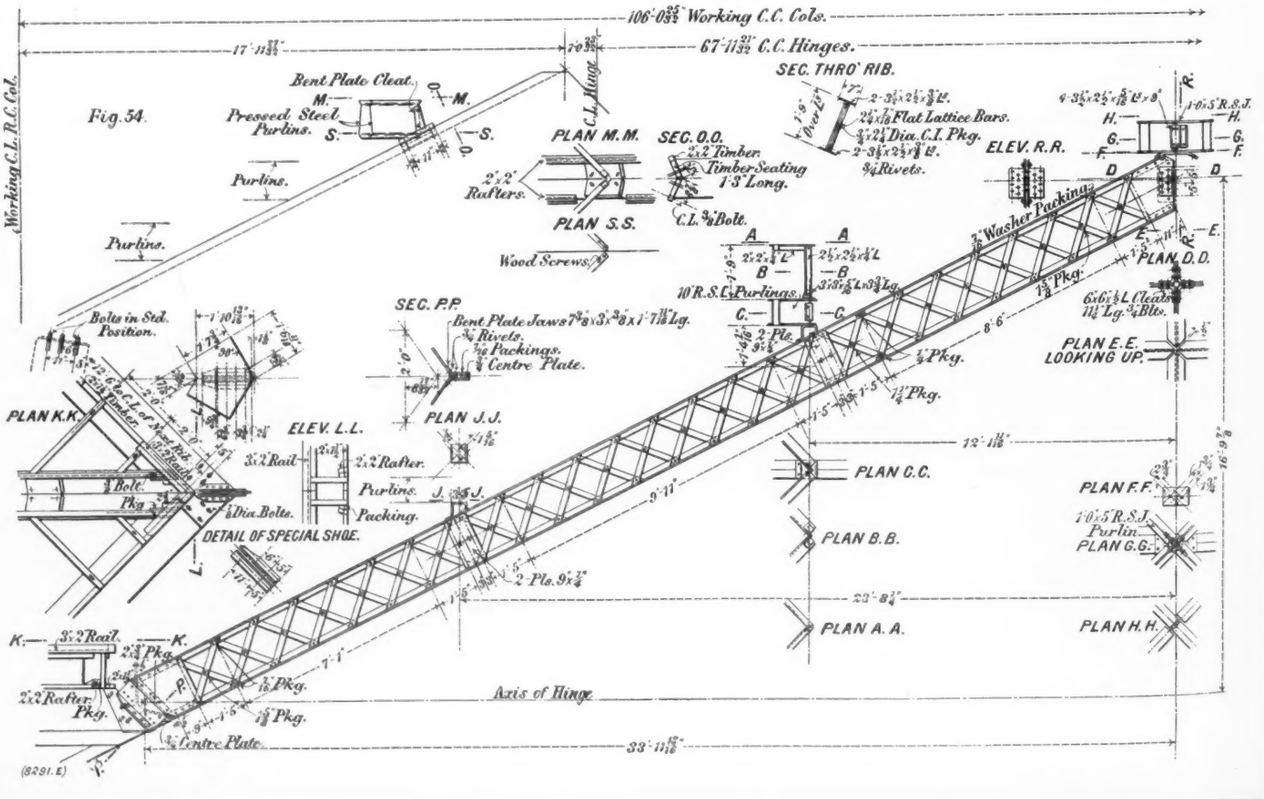
Fig. 47. Shuttering for Main Columns of 75-Ft. Aisle.

Fig. 48. View of 50-Ft. Bays, Showing Reinforced-Concrete Roof Principals.

THE PALACE OF INDUSTRY AT THE BRITISH EMPIRE EXHIBITION.

(For Description, see Page 291.)





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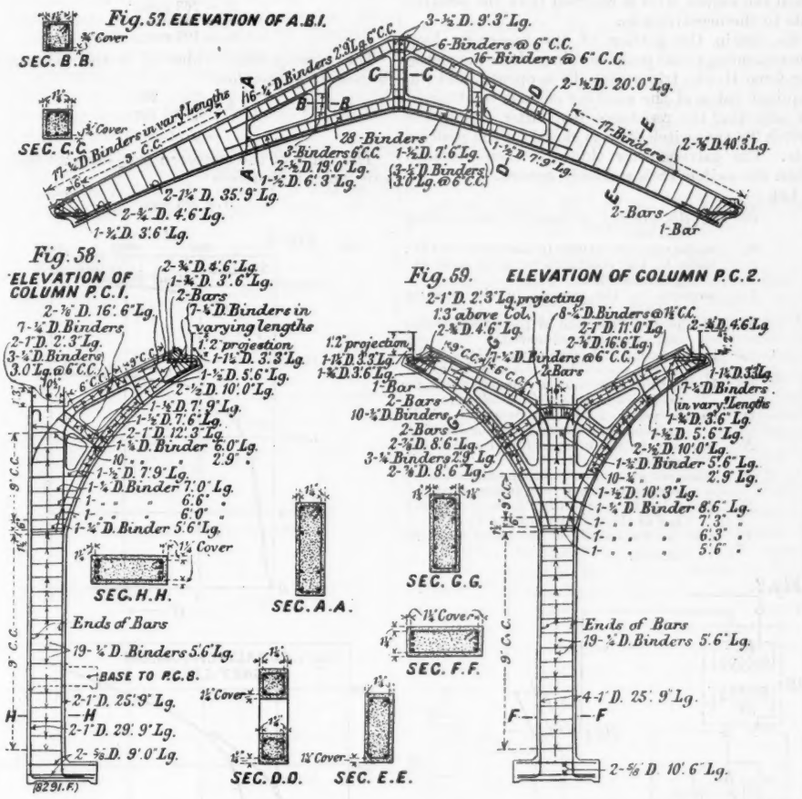
PALACE OF INDUSTRY; BRITISH EMPIRE EXHIBITION.



connection with the junction of the two gallery roofs are indicated in the small figures accompanying Fig. 54, and there is no need that they should be individually referred to here.

The construction adopted in the 50 ft. bays, to which we have already referred incidentally, is also of a very interesting type. Its general lines are well shown in Fig. 48 on Plate XXIII, while details of the columns and principals are given in Figs. 57 to 59 annexed. As will be seen, cantilever arms constructed as part of the columns have been adopted, cutting down the actual span of the main roof members proper, as in the case of the 75 ft. galleries. In this case, however, as the centre members of the roof principals are of reinforced concrete and are of the same cross-section as the cantilevers at the point of junction the effect of a continuous structure is obtained as will be seen from Fig. 48. This type of cantilever roof has lent itself particularly well to the reinforced concrete structure adopted, as it has enabled the main centre members to be kept down to a size and weight which could be handled without difficulty. Both the columns and principals are pre-cast, as will be gathered from Fig. 48, in which examples of each can be seen lying on the ground, so that no expensive shuttering had to be erected. The tops of the columns are connected by pre-cast reinforced-concrete guttering which sits in the Vee formed between the cantilever arms. Although the scale is somewhat small this guttering can be seen in Fig. 41. It may clearly be seen in Fig. 48. The whole arrangement of this roof gives an easily constructed and very effective type of structure.

The reinforced-concrete centre members are formed with undercut outer ends which rest on a correspondingly shaped saddle form on the cantilever end. These forms are shown in Figs. 57 to 59, while the joint between the two parts may clearly be seen on the left-hand principal in Fig. 48. The two members are located together and prevented from sideways movement by a 1¼ in. diameter bolt, which is cast into the cantilever end and passes through a formed hole in the roof principal. The 1¼ inch diameter bolts just referred to do not take any of the thrust due to the dead-weight or wind pressure, which are transmitted direct from one reinforced-concrete part to the other.

It will be clear that this arrangement leads to very simple and speedy erection. Details of the reinforcement of the columns and main beam are given in Figs. 57 to 59. These figures require no detailed comment. As will be seen from Figs. 58 and 59 two 1 in. diameter bolts are cast into the top of each column and project 1 ft. 3 in. These are for the purpose of securing the reinforced concrete guttering to which we have already referred.

A 12 in. by 5 in. steel joist is fixed at the ridge of the roof, four bolts being cast in the concrete beam for securing it. The purlins are of the special type illustrated in Fig. 53. They rest on a 2 in. timber seating, and are held down by four ⅝ in. bolts cast in the beam. Midway between each pair of reinforced concrete principals the purlins are stiffened by a 1¾ in. × 1¾ in. × ¼ in. angle carried through triangular holes in the webs and secured to them by steel wedges. As will be seen from Fig. 41 the centre portion of the roof has louvres borne by 2-in. timber framing secured to the topmost pressed-steel purlin. The upper part is covered with patent glazing supplied by Messrs. Mellowes and Co. The lower portions are covered with Trafford tiles clipped direct to the purlins. In concluding this description of these very interesting buildings, we must again thank the consulting engineer, Mr. E. O. Williams, B.Sc., for facilities placed at our disposal, and also Messrs. Sir Robert McAlpine and Sons, for information in relation to the actual constructional work. It is probable that when the exhibition opens in April, many of the engineering visitors will find these very remarkable buildings of more interest than many of the exhibits which they are to contain.

THE MAGNETIC TESTING OF SMALL SPECIMENS.

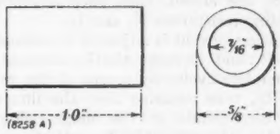
By T. F. WALL, D.Sc., D.Eng.

Introductory.—The magnetic testing of small specimens by a method which shall be simple, convenient and accurate for all values of the magnetising force H up to about 2,000 gauss, is a problem of considerable practical importance—particularly in connection with the manufacture of permanent magnet steels. For instance, the effect of heat treatment can be more satisfactorily studied when small samples can be tested, since it is easier to obtain a magnetically homogenous sample in a small volume than when a large mass is used for testing. Further, permanent magnet steels, particularly those containing cobalt, are rather expensive materials, and the cost of testing is appreciably reduced when small samples are used.

Methods for testing small samples have been described* which involve the use of a large electromagnet and which comprise the use of special H search coils in addition to the B search coil. Two or more H search coils are wound near the surface of the specimen, and these search coils are then connected in opposition in pairs and thus a measurement of the value of H near the surface is obtained.

If the test has to be carried out for values of H which are considerably greater than about 2,000 gauss, it is probable that some such method will be necessary. For the testing of the magnetic qualities of a specimen up to about 2,000 gauss, however, it is considered that the method described in the present article has considerable advantages both as regards the simplicity of the experimental work and also as regards the accuracy with which the measurement can be made over the whole range of H down to very small values.

Fig. 1. SAMPLE TEST PIECE.



A leading advantage of the method is that a closed magnetic circuit is used, and consequently no H search coils are necessary. There is therefore no difficulty due to free magnetism, since no free magnetic poles are developed in the specimen. A number of actual practical tests have been carried out by means of this method, and the results obtained are detailed in the latter part of the article. Some of the test results given in the curves of Figs. 3, 4, and 6, are new in so far as the writer is aware, and have not hitherto been published.

Description of the Method.—The sample to be tested is preferably in the form of a tube of the material, a convenient size being as shown in Fig. 1. This tube is wound with a search coil of about 40 turns of, say, No. 36 S.W.G. copper wire, double cotton-covered, and an exciting coil, which may also have about 40 turns of, say, No. 20 S.W.G. copper wire, double cotton-covered. The windings thread the tube so that the sample is magnetised in a circular direction coaxial with the tube, the lines (or sheets) of magnetic force being therefore coaxial cylinders. In this way the specimen is tested as a closed magnetic circuit, and no trouble arises from, and no correction is necessary for, any free magnetism since no free magnetic poles will be developed.

In order to obtain values of the magnetic force H of the order of 2,000 gauss, it will be necessary to pass a relatively heavy current through the exciting coil. For example, for the dimensions given in Fig. 1, the mean diameter of the magnetic circuit is ¼-in., that is, 1·35 cm. The mean length of the magnetic circuit is therefore 4·24 cms. If the exciting coil has 40 turns, the value of the exciting current I amperes necessary to give

* See, for example, Campbell and Dye, Journal of the Institution of Electrical Engineers, Vol. 54 (1915), page 35. Also Dictionary of Applied Physics, Vol. 2, pages 451 to 510.

a magnetic force of H gauss along the mean magnetic circuit is given by the relationship

$$\frac{4\pi}{10} \times 40 \times I = H \times 4{\cdot}24.$$

or

$$H = 11{\cdot}9\,I,$$

so that for H = 2,000 gauss, the exciting current I must be 168 amperes.

Now, obviously, this exciting current cannot be allowed to pass for any considerable length of time through the exciting coil because the wire being of relatively small diameter the coil would very soon burn out. In order, therefore, to provide against this contingency two precautions are taken, viz.:—

1. The specimen during the test is immersed in an oil bath.

2. A special switch is arranged so that the search coil may be short-circuited immediately after the galvanometer discharge is complete and the exciting circuit may then be broken without affecting the continued swing of the ballistic galvanometer (see Fig. 2).

Since, therefore, the exciting coil will only be allowed to carry the maximum value of the exciting current for, say, one or two seconds, the source of direct current supply may be, for example, a battery which is capable of giving the requisite current momentarily only. A battery of relatively small capacity therefore will be suitable for the purpose.

A complete diagram of connections is given in Fig. 2, which shows the switching arrangements suitable for obtaining the magnetisation curve (*i.e.*, the B-H curve), as well as the complete hysteresis loop, or, alternatively, the demagnetisation branch of the hysteresis loop.

For the magnetisation (B-H) curve, the switches TS and S_1 are closed, thus short-circuiting the corresponding resistances R_2 and R_3.

The exciting current is adjusted by means of the resistance R_1, and the magnetisation carried through several complete cycles by means of the reversing switch MRS, thus ensuring that the flux density correctly corresponds to the magnetising force. This operation of carrying the magnetisation through several cycles is completed by leaving the switch MRS open.

Short-circuiting the galvanometer by placing the switch SS on the contact *b*, the switch MRS is closed. The galvanometer is then connected in series with the search coil SC by moving the switch SS in the mid-position and the switch MRS is then reversed. As soon as the corresponding discharge through the galvanometer is completed, the search coil SC is short-circuited, and the switch MRS may then be opened without affecting the free swing of the galvanometer coil.

For very high values of the exciting current, the galvanometer throw corresponding to the complete reversal of the exciting current may be obtained in two distinct stages, viz.: (1) the throw due to the opening of the switch MRS, that is, due to the reduction of the magnetising force H from, say, a positive maximum to zero; (2) the throw due to the closing of the switch MRS on the reverse side, that is, the throw due to the increase of the magnetising force from zero to the negative maximum value.

It is usually advisable to obtain a few check readings by noting the galvanometer throw when the current is reversed in the opposite direction, say, from the negative maximum value to the corresponding positive maximum value. By means of the galvanometer reversing switch GRS the throw in all cases may be obtained on the same side of the scale zero.

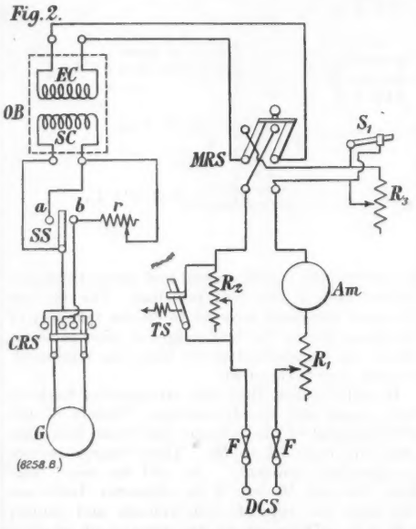
For the hysteresis loop the portion corresponding to the negative values of the magnetising force H is obtained by means of the switch S_1 and the adjustable resistance R_1, whilst for the portion corresponding to the positive values of H is obtained by means of the trip switch TS and the adjustable resistance R_2. For example, to obtain the portion of the hysteresis loop corresponding to negative values of H, the required maximum positive value of the exciting current is set by means of the resistance R_1, and the required negative value of the magnetising current is then obtained by opening the switch S_1 and adjusting the resistance R_3. The switch S_1 is then closed, and the magnetisation of the specimen carried through several cycles by means of the reversing switch MRS. The switch S_1 is then opened and the galvanometer throw obtained when the switch MRS is reversed from the positive side to the negative side.

To obtain the portion of the hysteresis loop corresponding to the positive values of the magnetising force H, the trip switch TS is opened, and the required value of the exciting current is obtained by adjusting the resistance R_2. After closing the switch TS the switch MRS is closed on the positive side. The galvanometer throw is then obtained when the switch TS is suddenly opened.

Let

- w_1 be the number of turns in the exciting coil EC.
- w_2 be the number of turns in the search coil SC.
- r ohms be the resistance in series with the galvanometer.
- I amperes be the current in the exciting coil EC.
- θ_1 be the first deflection of the galvanometer coil as actually observed.
- θ_2 be the second deflection of the galvanometer on the same side of the scale zero.
- θ_3 be the third deflection of the galvanometer on the same side of the scale zero.
- Θ be the value of the first deflection of the galvanometer as corrected for damping.
- A sq. cms. be the cross-sectional area of the specimen.
- B lines per sq. cm. be the magnetic induction corresponding to the exciting current I.
- H gauss be the magnetising force corresponding to the exciting current I.
- l_m cms. be the length of the mean magnetic circuit,

Fig. 2.



then it may be shown that the change of magnetic flux corresponding to a change of the exciting current from the value I to the value $\pm I^1$ is given by the relationship

$$N = \frac{K\,\Theta\,r\,10^8}{w_2}$$

If the current is reversed from the value + I to the value − I, the flux density B corresponding to the exciting current I is given by the relationship

$$B = \frac{K\,\Theta\,r\,10^8}{2\,A\,w_2}$$

The value of the magnetising force due to the exciting current I is given by the formula

$$H = \frac{4\,\pi\,I\,w_1}{10\,l_m}$$

In order to find Θ the corrected value of the galvanometer deflection from the observed deflection, it is necessary to determine the logarithmic decrement. This is given by the formula

$$\lambda = \frac{1}{4}\log_e \frac{\theta_1}{\theta_3}$$

and this decrement must be obtained for each value of the galvanometer resistance r used.

The value of the first deflection as corrected for damping is then given by

$$\Theta = \theta_1\left(1 + \frac{\lambda}{2}\right).$$

For example, in a certain test the galvanometer resistance r was 8,000 ohms. The observed values of the galvanometer deflections were as follows:—

$\theta_1 = 263$ mm.
$\theta_2 = 169$ mm.
$\theta_3 = 107$ mm.

The corresponding value of λ the logarithmic decrement is therefore

$$\lambda = \frac{1}{4}\log_e \frac{263}{107}$$
$$= 0{\cdot}225.$$

The value of the corrected first swing of the galvanometer is therefore

$$\Theta = 293 \text{ mm.}$$

Fig. 3.

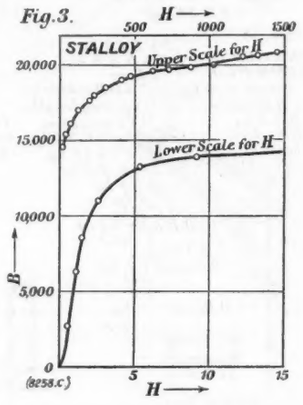
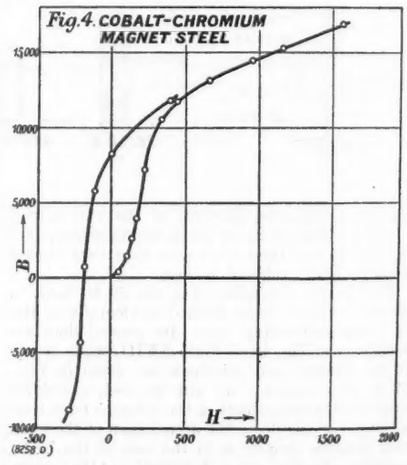


Fig. 4. COBALT-CHROMIUM MAGNET STEEL



The galvanometer constant K in the formulæ may be conveniently determined by noting the galvanometer throw when a standard condenser charged to a known voltage is discharged through the galvanometer. For example, in a certain calibration test, a standard condenser of 1 mfd. capacity was charged by a standard Weston cell to a voltage of 1·018 volts. When this condenser was discharged through the galvanometer, the following values of the deflection were observed viz.:—

$\theta_1 = 209$ mm. $\theta_2 = 179$ mm. $\theta_3 = 152$ mm.

The logarithmic decrement in this case was accordingly

$$\lambda = 0{\cdot}08$$

and the corrected value of the first swing of the galvanometer was therefore

$$\Theta = \theta_1\left(1 + \frac{\lambda}{2}\right) = 218 \text{ mm.}$$

Hence the galvanometer constant was

$$K = \frac{1{\cdot}018 \times 1}{218 \times 10^8}$$

that is,

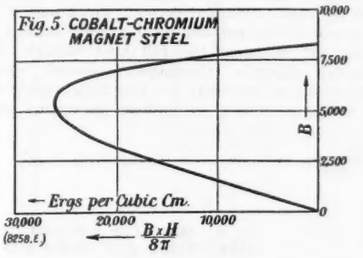
$$K = \frac{4{\cdot}66}{10^9}$$

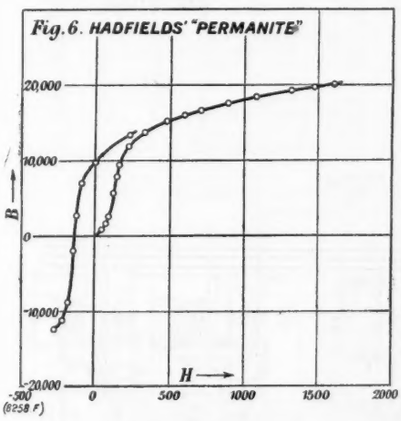
coulombs per mm. scale deflection.

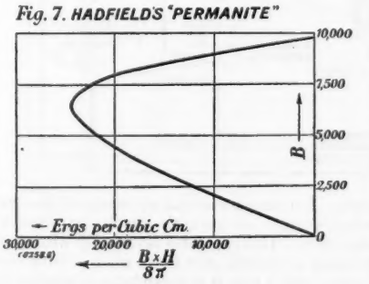
In Fig. 3 is shown the magnetisation curve (that is, the B-H curve) for "Stalloy." A small

tubular sample of the material was prepared and then annealed before the test was made. The test was carried out for values of the magnetising force up to about H=1,500 gauss. In Fig. 4 is shown the B-H curve and also the demagnetisation curve for cobalt-chromium magnet steel as supplied by the Cobalt-Magnet Steel Company Sheffield. This sample contained 9 per cent. cobalt 9½ per cent. chromium and 1 per cent. carbon. The steel was hardened by heating up to 1,000 deg. C. and then allowed to cool in air.

It was shown by Evershed* that the proper criterion of merit for permanent magnet steels is the maximum value of the product B × H as obtained from the demagnetisation curve. If the







maximum value of this product be divided by 8π the result gives the maximum available energy in ergs†.

In Fig. 5 the values of $\frac{B \times H}{8\pi}$ are plotted as a function of the induction density B for the whole of the demagnetisation curve and it will be seen that for this sample of cobalt-chromium steel the maximum available energy is about 26,200 ergs per cubic cm. The coercive force is $H_c = 180$ gauss, and the remanent induction density is $B_{rem.} =$ 8,300 lines per sq. cm. In Fig. 6 are given the B-H curve and the demagnetisation curve for Messrs. Hadfields' brand of permanent steel known as "Permanite" the test having been made for values of the magnetising force up to 1,600 gauss. For this sample the value of the remanent induction density was $B_{rem.} = 9{,}800$ and the coercive force $H_c = 138$. In Figs. 7 the values of $\frac{B \times H}{8\pi}$ are plotted as a function of the induction density B for the demagnetisation curve and it will be seen that the maximum available energy of this steel is about 24,400 ergs per cubic cm.

In conclusion, the author desires to express his thanks to Mr. S. A. Main, of Messrs. Hadfields, Ltd., and to Mr. J. F. Kayser, of the Cobalt Magnet Steel Co.. Ltd., for supplying the samples of magnet steel. The sample of Stalloy was supplied by Messrs. Joseph Sankey and Sons, Ltd.

* See S. Evershed, "Permanent Magnets in Theory and Practice," Journal of the Institution of Electrical Engineers, Vol. 58, pages 816-818, September, 1920.

† See also "Electrical Engineering," T. F. Wall, Chapter VIII.

33,000-VOLT BULK SUPPLY SCHEME FOR GORSEINON.

(*Concluded from page* 262.)

In dealing with the details of the switch gear we naturally propose chiefly to pay attention to the 33,000-volt installation, as sub-station gear built to operate at this pressure is still somewhat of a novelty in this country. A diagram of connections of the whole station is given in Fig. 6, on page 296, the 33,000-volt board connections being shown in the upper part of the diagram. A cross-section through the incoming feeder panel of the 33,000-volt gear is given in Fig. 7, on page 297, while a rear view of the cubicles is given in Fig. 8 and a cross-section through the outgoing feeder panel in Fig. 9.

As will be seen, there are four cubicles, one controlling the incoming feeder from Swansea, two controlling the 33,000-volt sides of the transformers and one controlling the outgoing feeder to Pontardulais. The cubicles are built on an iron framework and each is separated from the next by moulded stonework slabs. The cubicles are further divided by stonework slabs separating the phases. Horizontal stonework slabs separate the bus-bars, while the connections to them from the isolating switches are separated in the same way. All cubicles are closed by sheet steel doors at the back and front. Separate doors are arranged for each phase and each compartment. The whole arrangement will be easily followed from Figs. 7 to 9, while the general appearance of the cubicles will be seen from the interior of the sub-station given in Fig. 25, on page 306.

As will be seen from the diagram, Fig. 6, and the side view given in Fig. 7, the incoming feeder cubicle contains two sets of isolating switches and potential and current transformers for operating the watt-hour meters, ammeters and power-factor meter. In both cases the transformers are of the oil-immersed type. The switches, which are operated by a lignum vitæ pole divided into two parts by a porcelain insulator, enable the transformers to be completely isolated. No oil switch is used, or is necessary on this cubicle, as the protection of the feeder is ensured by the oil switch at the far end of the line at which the power is supplied. The transformer cubicles each contain an oil switch and knife switches by means of which it may be isolated from the bus-bars. The panels also contain current transformers for operating the overload relays of the oil switches. The outgoing feeder panel shown in Fig. 9 is fitted the same as the transformer panels, except that an extra set of isolating switches is fitted on the far side of the oil switch. The porcelain insulators between the compartments are designed to prevent any fumes which may escape into the oil-switch compartment from passing to any other compartment. Each phase of the oil switch is, of course, in a separate tank.

The oil switches, which form one of the most interesting details of the whole installation have each a breaking capacity of 350,000 k.v.a. The break in each phase is a double one making a total length of 16 in. The head of oil above the contacts is 11 in. and the oil in each tank amounts to 22 gallons, giving a total of 66 gallons per switch. The switch contacts and oil tank for one phase are illustrated in Figs. 10 and 11, on page 297. The tank is of welded steel and is reinforced with channel and angle irons, as shown in the general view given in Fig. 19, on page 298. This is a front view of one of the switch cubicles with the steel doors of the compartments of one phase removed. A strong mechanical construction of this type is essential for tanks of oil switches of large capacity owing to the internal conditions which may arise when a short circuit is interrupted. The tank is held in position by steel bolts which secure it to the top frame, long bolts being also provided so that the tank is supported when it is lowered for the inspection of the contacts. The tank fits into a deep recess in the top frame which is fitted with a gasket, the arrangements being shown in Figs. 10 and 11. This prevents emission of fumes from the tank into the cubicle, but the inside of the tank is ventilated by a vent pipe, which puts the tank in communication with the outside air. The tanks are lined with three-ply birch wood. This particular wood is used as it is non-resinous; with a resinous wood there is danger that the resin may get into the contacts of the switch and interfere with their free opening. To lower the tanks for inspection of the contacts or other purposes a truck is provided which may be run into any of the oil-switch cubicles. This is illustrated in Figs. 20 and 21, on page 299. The arrangements of this truck are simple, and will be understood from the figures without any extended explanation. As will be seen the tank is lowered by means of a platform which is suspended by a wire rope and runs on rollers on the uprights of the truck. The wire rope is carried round pulleys driven by a worm gear and this gear is in turn operated by a star handle.

The moving contacts of the switch are wedge-shaped and work between fixed contacts of controller pattern, as shown in the detail given in Fig. 12. This form of contact is found to have good wearing qualities and a low milli-volt drop.

Sparking contacts to take the final break are fitted as shown in Fig. 10. These sparking contacts are made long enough to ensure that the contacts shall be separating at a high speed at the time of rupture. This question of a high speed of break has received considerable attention in the design of the switch and the moving contacts actually travel downward at a speed of about 5 ft. per second, corresponding to a total speed of rupture of the circuit of 10 ft. per second. When the switch operates under short-circuit conditions this speed is increased by the magnetic blow-out effect. As the moving parts of the switch are naturally fairly heavy, air dashpots are provided to check them at their lower position in order that the weight and high-speed may not lead to shock or damage.

The switch may be arranged for operation either electrically through a solenoid, or by hand. The actual levers by which the moving contacts are lifted are situated inside the cubicles, as shown in Fig. 9, but the whole of the operating mechanism is fixed outside as can be seen in Fig. 19 and in Fig. 25, on page 306. It is thus well removed from the neighbourhood of any high-tension connections, and is fully open to inspection. A single operating gear serves for the three phases of a complete switch, and is connected up to the three sets of lifting levers in the cubicles by horizontal rods, one of which can be seen in Fig. 9. The operating mechanism itself can be seen in Fig. 9, but is illustrated to a larger scale and in greater detail in Figs. 13 to 18, on page 298. In the Gorseinon installation the switches are hand-operated, a hand lever pedestal for each switch being fixed in front of the cubicles. One of the pedestals can be partly seen behind the second transformer in the interior view of the Gorseinon sub-station given in Fig. 25. The arrangement is, however, better shown in Fig. 24. which is an interior view of the Pontardulais station. This view is taken looking towards the 3,300-volt gear, but the operating pedestals for the two 33,000-volt switches can clearly be seen in the centre of the station. The two stations are identical except that there is no 33,000 volt outgoing feeder at Pontardulais.

The operating mechanism for the oil switch is the same for either electrical or hand operation, and the gear installed at Gorseinon may at any time be converted to electrical operation by adding an operating solenoid. The arrangement illustrated in Figs. 13 to 18 shows such a solenoid in position. The solenoid is shown at *a* and, as will be seen, it is connected up to the closing mechanism by the link *e*. As, however, the switches with which we are here concerned are, at present, fitted for hand operation only, it will be well to describe the mechanism from the point of view of hand control,

but the description will, we think, make it obvious that solenoid operation will give the same effect as the hand lever. The handle in the operating pedestal is connected through a series of links and levers to the shaft *b* of Fig. 13. This shaft is extended across the framework carrying the mechanism, which is shown in Fig. 19, and a rod carried behind one of the uprights connects an arm on the shaft *b* with a bell-crank lever under the floor connecting up to the hand lever. In the position of the mechanism indicated in Fig. 13 the switch is closed. It is brought into this position by rotating the shaft *b* in the direction indicated by the arrow. This action pulls on the link *i*, which at one end is pivoted to the arm carried by the shaft *b* and at the other to the member *f*. This member is pivoted on, but is not secured to the shaft *c*.

The member *f*, as will be seen from Fig. 14, is made up of two plates set some distance apart and connected by cross-pins. One of these pins carries the lever *m*, which is provided with a groove in which the end of the catch *g* fits. This catch *g* is keyed to the shaft *c*. When the switch is open the gear lies in the position shown in Fig. 17. On the operation of the hand lever, however, it is pulled by the link *i* to position shown in Fig. 13, and is held in position by the pin at the end of the lever *h*, which falls over a projection on the member *f*. The movement of the member *f* from the position shown in Fig. 17 to that shown in Fig. 13 results in the partial rotation of the shaft *c*, owing to its connection to the catch *g*. The shaft *c* carries arms, two of which are shown in Fig. 14, and these arms connect to the switch levers inside the cubicles by horizontal rods which have already been referred to. Two of these rods are shown in section at *d d*, in Fig. 14.

It will be clear that this operation of closing the switch can equally be effected by energising the solenoid *a* in the case of electrically-operated switches, as by the rotation of the shaft *b* by hand. When such electrical operation is used, arrangements are made so that the current is cut off from the solenoid immediately the switch is held by the lever *h*, so that there is no continuous consumption of current. An air-inlet valve is fixed at the top of the solenoid. This valve is detailed in Fig. 15, while an alternative arrangement of the solenoid and valve is shown in Fig. 18.

The tripping of the switch is carried out by the coil *k*, which is energised from the current transformers. The General Electric Company's biassed, relay system of protection is used in connection with the switches on the transformer panels, while a time limit is incorporated in the case of the Pontardulais feeder. These appliances determine the conditions under which the plunger of coil *k* rises and trips the switch. We will refer to the biassed relays more in detail later, but should first describe the operation of the actual switch-tripping mechanism. This will be followed from Figs. 13, 16 and 17. Pivoted to the member *f* there is a trip level *l*, which is formed with a curved tail. This lever is tripped by the rising of the plunger of coil *k*, and owing to the long tail the action takes place in any position of the mechanism. This will be clear from a comparison of Figs. 13 and 17. The arrangement prevents the switch being closed against a short circuit, or heavy overload. The position of the lever *m* with reference to the member *f* is controlled by a toggle which is shown in Figs. 13, 16 and 17. As will be seen, the trip lever *l* carries an adjustable stud near its pivoted end, and when this lever rises owing to the action of the trip coil this stud breaks the dead-centre of the toggle, so that the lever *m* partly rotates and releases the end of the catch *g*, with the result that the switch opens. As the catch *g* is carried round by the weight of the opening switch it comes in contact with a stud on the lever *h*, and lifts this, as shown in Fig. 16, so that the member *f* is released and the whole gear falls into the open position shown in Fig. 17. As will be seen from Fig. 13, the link *i* connecting the mechanism with the hand-operating gear is formed with a slot so that when the switch opens, the mechanism can fall into the position shown in Fig. 17 without it having to pull over the hand-operating lever and its connections. The arm on shaft *b* to which the link *i* is attached is made in the form of a socket, so that a lever may be inserted, and the gear operated from this point if desired. The arrangement gives an alternative hand operation in the case of electrically-operated switches.

As already mentioned, and as indicated in Fig. 6, the transformer switches are controlled by McColl biassed relays. This system gives protection against faults of any kind including leaks to earth, between phases and even between turns of the same phase. The special feature of the system is that the biassed arrangement gives equal protection, at all loads. If, for instance, a bias of 10 per cent. is given the relay will operate and trip the switch if the leakage current amounts to 10 per cent. of the main current, no matter whether the normal load, or an overload, be on the line. This may be compared with a system in which relays without a bias are used. If such relays were set to operate with a fault current of 10 per cent. of the normal load current good protection would be given, but if a heavy overload occurred many times the normal load, a defect of only ½ per cent. in balancing the current transformers might give rise to an increased excess current, 15 per cent. to 25 per cent. of the normal. This would exceed the trip value which was fixed at 10 per cent. of the normal. For this reason the setting of unbiassed relays is usually fixed at 100 per cent. of normal current, which means that a circuit is not cut out until a fault current has developed to equal the full load current. This General Electric Company's biassed system eliminates the necessity for this high setting and, as we have said, gives uniform protection at all loads. A further incidental advantage of the system is that current is constantly circulating through the relay coils. This compares favourably with systems in which a current only flows when a fault occurs, since in such a case it is possible for a break to exist in the connections without its existence being suspected and for the protective system to prove unworkable just when it is required. A broken connection in the biassed relay system causes the relay to operate if there is not less than 20 per cent. load on the circuit.

The relay consists of a pivoted beam carrying a laminated plunger at each end. Each plunger works inside a coil. One of these coils tends to pull down the end of the beam carrying the trip contacts, and is called the operating coil, while the other coil tends to prevent the beam from tripping, and is called the restraining coil. The latter is supplied with current from the secondaries of both incoming and outgoing current transformers connected in series, which current is thus proportional to the main load. The operating coil, on the other hand, is connected across the leads joining the two secondaries, and hence carries the difference between the currents in these. Now the current transformer ratios are so proportioned that when all is in order, there is no difference current, the value of this, when it occurs, being proportional to a leak within

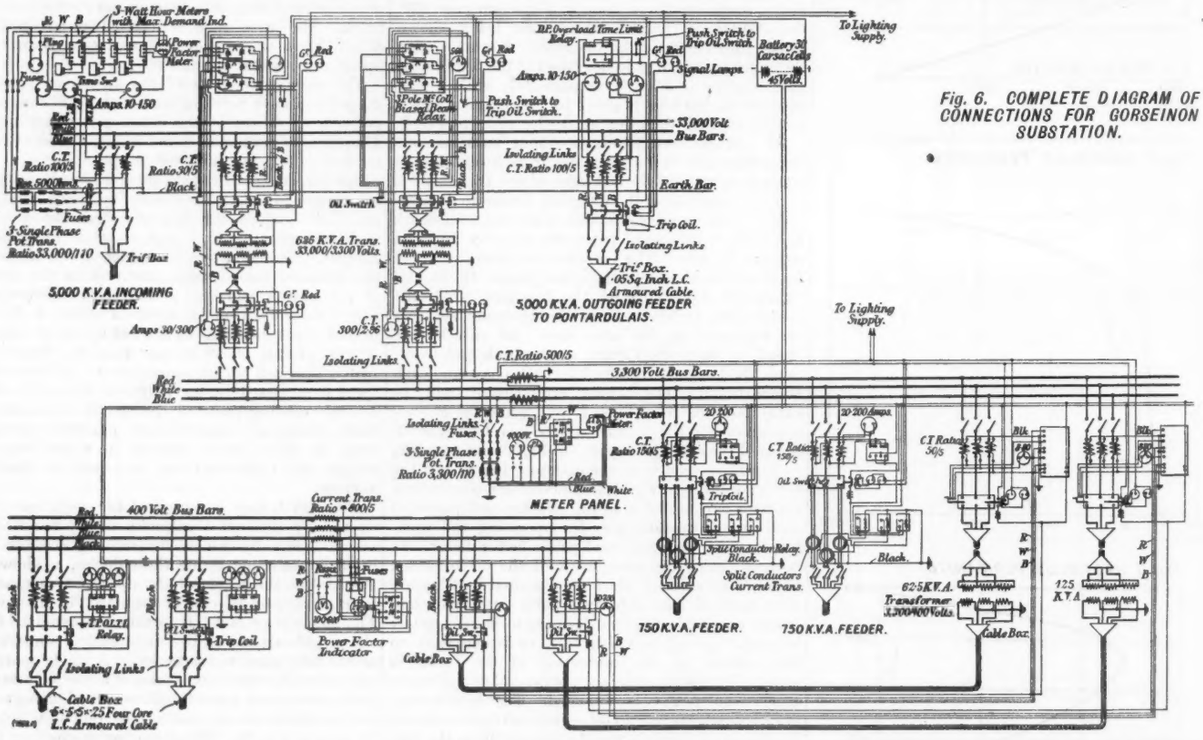


Fig. 6. COMPLETE DIAGRAM OF CONNECTIONS FOR GORSEINON SUBSTATION.

33,000-VOLT BULK SUPPLY SCHEME FOR GORSEINON.

MESSRS. ARTHUR ELLIS AND PARTNERS, ENGINEERS, CARDIFF.

Fig. 7. SIDE VIEW OF INCOMING PANEL. Fig. 8. 5000 K.V.A. INCOMING & METERING CUBICLES. 625 K.V.A. TRANSFR CUBICLE. 625 K.V.A. TRANSFR CUBICLES. OUTGOING FEEDER TO PONTARDULAIS.

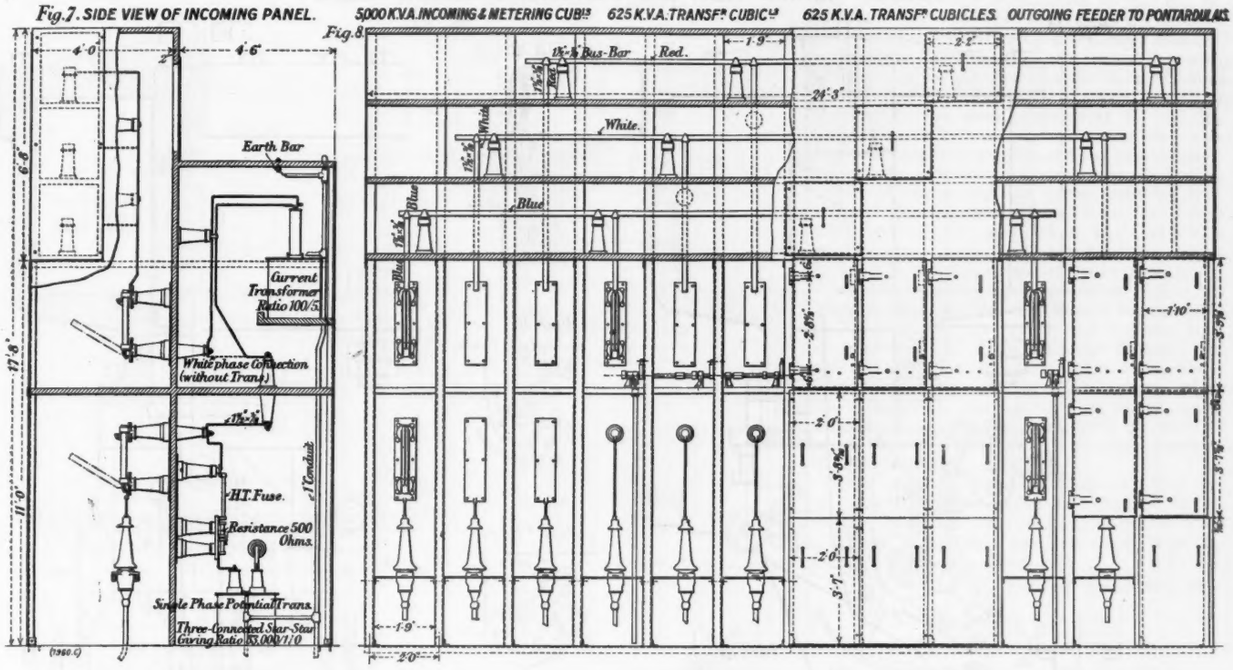


Fig. 9. SIDE VIEW OF OUTGOING FEEDER.

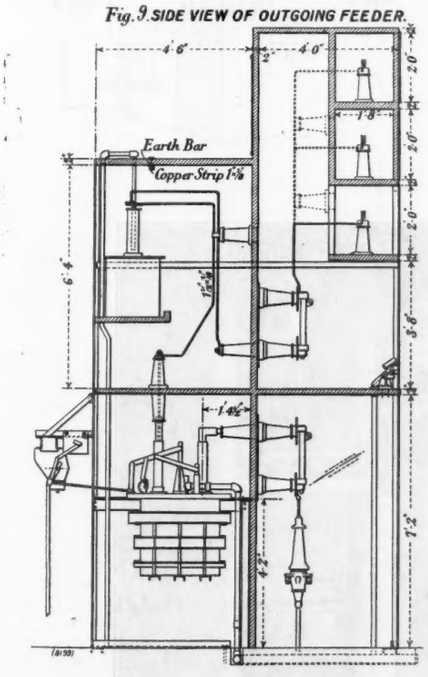
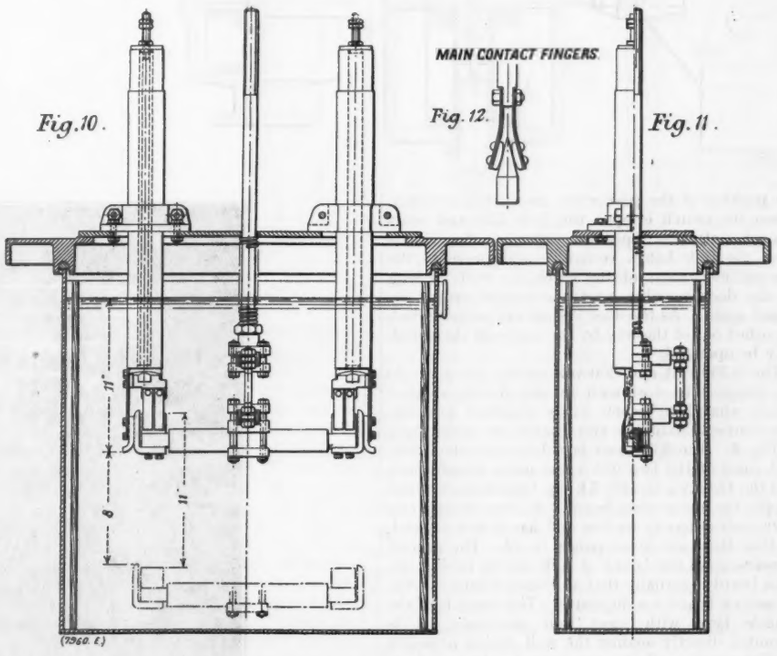


Fig. 10.



MAIN CONTACT FINGERS.

Fig. 12.

Fig. 11.

the transformer. The relay is tipped by such a current when its magnitude, multiplied by the number of turns in the operating coil, exceeds the "load" current multiplied by the turns of the restraining coil. Then by giving the latter coil, say, 10 per cent. of the number of turns in the former, the relay is made to operate when the fault current exceeds that per cent. of the load current that happens to be flowing. In this way the bias is obtained. The sensitive operation made possible by this system is of importance, as the great majority of transformer faults originate as small leaks between adjacent turns, which ordinarily have to continue burning the insulation until the damage is sufficient to trip the less sensitive relays.

The transformers which operate these relays are fixed in the switch cubicles, but the relays themselves are placed on instrument pillars fixed alongside the operating handles. The pillars which also carry the ammeters, indicating lamps which show when the switch is open or closed and a push button for tripping the switch by hand, can be seen in Figs. 24 and 25.

The only other feature in connection with the 33,000-volt switch gear to which we need refer is the interlock which is provided between the switch and the doors giving access to the isolating links at the back of the board. The arrangement is such that the isolating link chamber cannot be opened unless the oil switch is open, so that current cannot be broken on the links. The arrangement is quite a simple one and is illustrated in Figs. 22 and 23, on page 299. The relationship between this gear and the switch itself will be followed from the cross-section of the outgoing feeder panel given in Fig. 9. As will be seen the arrangement consists of a catch connected to the oil-switch operating mechanism and engaging a hasp on the inside of the door when the switch is closed. The catch, as will be seen in Fig. 23, forms one arm of a bell crank lever, another arm of which connects up to the link leading to the switch-operating mechanism. This bell crank lever has a third arm which comes in contact with a swinging link which is pivoted to the cubicle partition. This is shown in Fig. 23, which illustrates

33,000-VOLT BULK SUPPLY SCHEME FOR GORSEINON.

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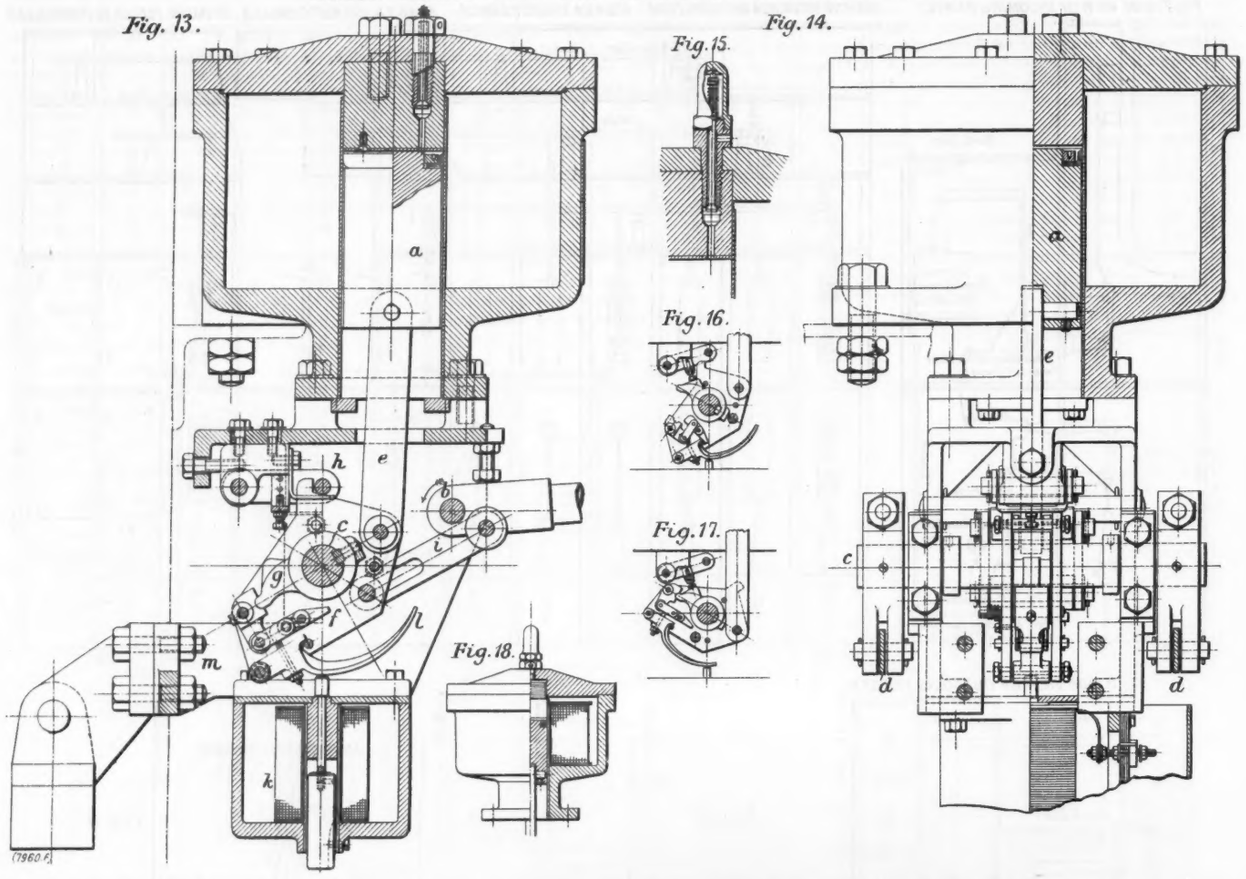

the position of the gear when the switch is closed. When the switch is open this link falls and rests against a stud on the door, and when the door is open the link hangs vertically and prevents the upward movement of the catch, so that as long as the door remains open the switch cannot be closed again. As the door is shut the swinging link is pushed out of the way by the stud and the switch may be operated.

The 3,300-volt and 400-volt switch gears we do not propose to deal with in any detail, as they follow what has become fairly standard practice. The connections of the two boards are given fully in Fig. 6. The 3,300 volt board controls the 3,300-volt sides of the two 625 k.v.a. main transformers and the 125 k.v.a and 62·5 k.v.a. transformers which supply the low-tension board. It also controls two 3,300-volt outgoing feeders and has a meter panel, so that there are seven panels in all. The general appearance of the board is well shown in Fig. 24. This board is actually that at Pontardulais, but the Gorseinon board is a duplicate. The board is of the cubicle type with sheet iron partitions. It is mounted directly against the wall, and is arranged so that access to all apparatus may be obtained from the front. The switches are of the direct hand-operated type, and hinged doors are provided above and below them, so that either the top of the switch or the oil tanks may be got at without disturbing the setting of the switch in any way. These doors are both interlocked with the switch mechanism, and neither can be opened while the switch is in the closed position. The usual isolating links, indicated in Fig. 6, are fitted to disconnect the switches from the bus-bars. The switches on the main transformer panels are of larger capacity than those on the other. This will be evident from the appearance of the hand levers in Fig. 24.

It will be seen from the diagram of connections, Fig. 6, that the 400-volt board is of the four-wire

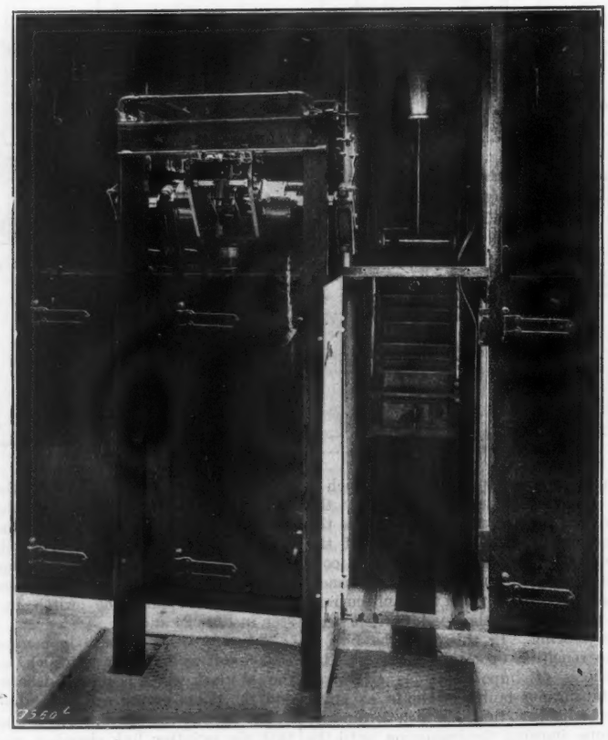

FIG. 19 CIRCUIT BREAKER.

33,000-VOLT BULK SUPPLY SCHEME FOR GORSEINON

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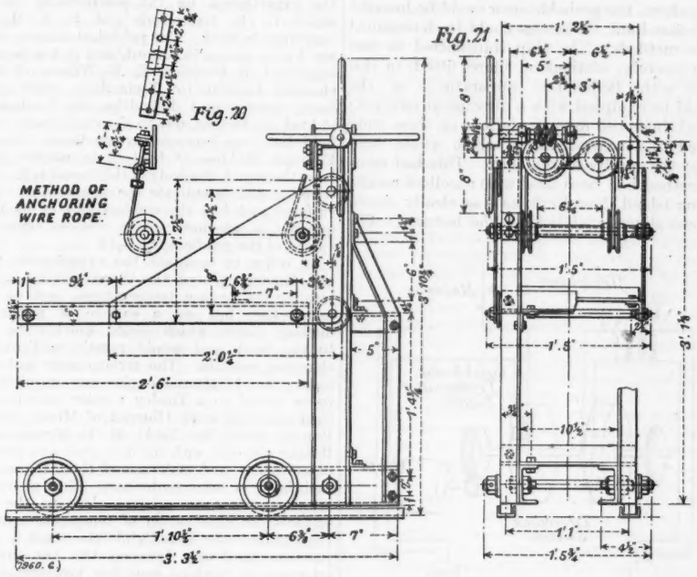
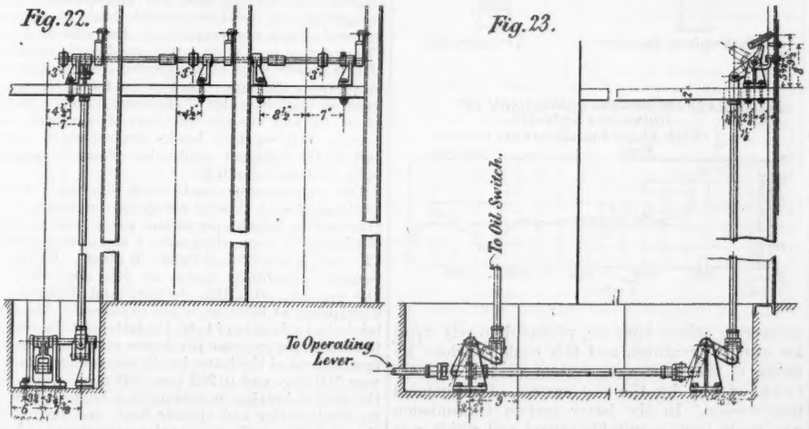




type, the low-tension sides of the 125 and 62·5 kw. transformers being connected in star with an earthed centre. The board is generally on the same lines as the 3,300-volt board. As shown there are two four-wire outgoing feeders. These feed the overhead network. The arrangement gives either 400 volts or 230 volts and at Gorseinon will gradually replace the existing direct-current network. At Pontardulais, which is a new area, a considerable four-wire overhead network has already been established. The work was carried out by Messrs. Johnson and Phillips, Limited, of Charlton. In concluding our description of this interesting installation we have to thank Messrs. Arthur Ellis and Partners for information and other assistance supplied, as well as Mr. J. H. Dent, resident engineer, for the Gorseinon Electric Light Company, who conducted our representative over the works and also Messrs. The General Electric Company for drawings and other material placed at our disposal.

MODERN NAVIGATION DEVICES.

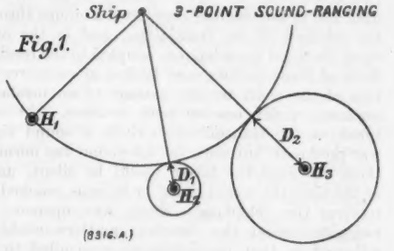
IN his Royal Institution discourse of February 29, on "Some Modern Navigation Devices," Mr. F. E. Smith, F.R.S., Director of Scientific Research to the Admiralty, limited himself to four types of devices based upon the acoustic and electromagnetic properties of sea water and the directional properties of radiotelegraphy. The lecture was a noteworthy achievement both as to exposition and demonstration.

Mr. Smith first demonstrated the use of the leader gear* by the aid of which a ship, he explained, could find its way into a harbour. An insulated cable was laid on the bottom of the channel, and was fed with alternating currents of 450 periods, the return being made through the sea water. The induced currents were picked up by two coils connected to a telephone, mounted outboard on each side of the ship, not less than 1½ ft. from the side. These coils made an angle of 75 degrees with the horizontal, and had at least 2 ft. of the vertical side of the hull above the upper edge of the coil. As the ship deviated from the line of the cable, the sound heard in the telephones became weaker; signals were good up to 400 yards, and if the ship towed a two-conductor cable, fitted with electrodes 100 yards apart transverse to the course, signals could be detected at distances up to and over 1,200 yards. By means of a ship model and a cable placed on the lecture table, Mr. Smith also showed that visible signals could be given, a red or a green lamp which glowed brightly while the ship kept its course over the cable was extinguished as the vessel moved away from the cable; that arrangement, however, was not in practical use so far. A submarine bell at the end of the cable, the author remarked, would extend the range by many miles. The leader cable was efficient, but was expensive both to install and to maintain.

For position-finding at sea, Mr. Smith proceeded, sub-aqueous sound ranging and radio-acoustic methods were available. When an explosion—a few ounces of guncotton exploded 2 ft. or 3 ft. below the surface, he said, were sufficient for a range of 50 miles—was started from the ship, and shock receivers were placed at H_1, H_2, H_3 (Fig. 1), the pressure wave would strike the receivers after intervals depending upon the ship's distance.

If, with H_2 as centre, a circle were drawn with radius D_1 of length equal to the distance sound would travel in the difference between the times recorded by the shock receivers at H_1 and H_2, then the position of the ship must be at the centre of a circle passing through H_1 and touching the circle drawn with radius D_1, as above described. An infinity of circles could be drawn satisfying this, and to discriminate between them, the third shock receiver was provided at H_3. With this point as centre a second circle was drawn with radius D_2 equal to the distance sound would travel in the interval between the times recorded at H_1 and H_3. The position of the ship was then at the centre of the circle passing through H_1 and touching both these circles. Arrangements were provided for automatically starting the recorders through the agency of "sentry" receiver placed further out to sea. The time intervals were measured by a suitable chronometer, which recorded the times at which circuits were broken at the respective "shock" receivers.

Experimenting at the St. Margaret's Bay Admiralty Station, Dr. Wood and Captain H. E. Browne had found the velocity of sound V in sea water to be about four and a-half times the



velocity of sound in air, the velocity being given by the formula $V = 4756 + 13{\cdot}8\,t - 0{\cdot}12\,t^2 + 3{\cdot}73\,(S - 35)$ in feet per second. In this formula t is the temperature and S the salinity of the water, the formula holding over the range $t = 6$ to 17 deg.C. and $S = 35$ parts per thousand. Using four shock receivers at St. Margaret's, the extreme distance apart being 14 miles, very accurate fixes had been obtained, as long as the ship's distance was not very great compared to the base line. In the latter case the lines, from the intersection of which the actual position was deduced, would cut at very acute angles. In such cases either the base must be lengthened, or radio-telegraphic signals must be employed in addition. For this purpose the explosion was made to close a radio-circuit, and the signal received on an ordinary aerial deflected one of the galvanometer strings. The radio-signal being practically instantaneous, the interval between the reception of this signal and that of the shock, multiplied by the velocity of sound, gave the distances between the ship and the shock receiver. This method of location, Mr. Smith remarked, seemed to be most accurate and reliable, in daytime, at night, and in all weather conditions and at all seasons.

The lecturer passed on to consider sonic depth sounding by the echo method, which, he said, might ultimately play an important part in general navigation and in submarine cable laying. To ascertain the depth of the water at any spot, we might directly measure the time interval elapsing between a single sound impulse and the arrival of its echo; or we might make impulse and echo follow one another at such a period that the echo of the first impulse would coincide with the second impulse; or we might arrange for reception to be possible only during an exceedingly short, but adjustable time interval. Success, the lecturer stated, had attended all these methods. The sounds should be sharp and should consist of a single impulse or a series of impulses; Marti, in

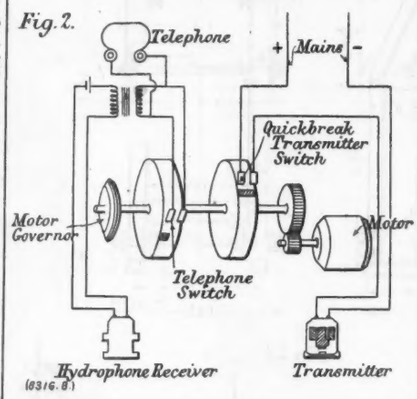
* See ENGINEERING, February 18, 1921, page 187.

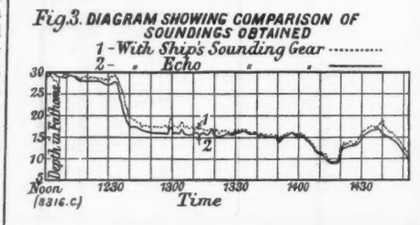
France, discharged a rifle or small gun into the water, while Behm, in Germany, employed a detonator, fixed to the ship's side above the water line, to start a rotating mirror, the motion of which was stopped by a receiving microphone. The United States Navy had used a sonic depth sounder for obtaining a line of soundings between America and Gibraltar, by the second coincidence method mentioned above. They had not, however, been able to use the method for depths of less than 40 fathoms. For smaller depths, especially over sloping bottoms, Dr. H. C. Hayes used a direct-angle method, placing one line of twelve hydrophones well forward, and another line well aft; the receivers were non-resonant and capable of phase adjustment.

In the apparatus devised by the Admiralty Research Department, the source of sound was a steel diaphragm, 5 in. in diameter, fixed to the hull of a ship. The diaphragm was struck by a spring hammer controlled by a solenoid, the circuit of which was automatically broken every half second for 1/400th of a second, the note emitted by this receiver, having a frequency of 1,250 vibrations per second, was heavily damped by the water. The receiving hydrophone was a simple aperiodic microphone of the type developed by Sir W. Bragg and his collaborators during the war.* Installed on board was a ½-h.p. electric motor running at 1,200 r.p.m., and provided with a special centrifugal friction governor, driving through a 10 to 1 reduction gear a shaft, on which were mounted two discs (Fig. 2). Two brushes rested on each disc, and in the one case completed a circuit through the solenoid of the transmitter, and in the other short circuited the telephone coupled to the receiver. Both of these circuits were broken at every revolution of the shaft by the passage of an insulating segment, under one or both brushes. At each break at the transmitting switch, a sound signal was produced, but since the telephone was normally short circuited the latter would be silent, unless at the time the sound signal or its echo reached the receiver the telephone switch was opened. By swinging round the brushes, matters could be adjusted so that the telephone responded to the signal or its echo. This displacement of the brushes was, of course, a measure of the time taken for the sound signal to reach the bottom and come back again. With the disc rotating twice per second, brush displacement of 18 degrees would correspond to $18/2 \times 360 = 1/40$ second; the velocity of sound in water being 4,935 ft. per sec. at 15 deg. C., the sound would have travelled 123 ft., and the depth of the water would be 10 fathoms.

The short-circuiting of the telephone, except for very brief intervals, Mr. Smith pointed out, had the advantage that the observations were not disturbed by noises on board the ship. The curves, Fig. 3, showed how well the instrument had functioned on a survey vessel, steaming at 6 knots under conditions sufficiently unfavourable to account for a 4-ft. difference between the Somerville wire-gear soundings (indicated by the dotted curves) and the echo soundings (indicated by the full line curve), which were otherwise in remarkably close accord. So far, the apparatus had given satisfactory results in shallow water and in water up to 35 fathoms in depth, but instruments for greater depths were under construction. In a remarkable demonstration the lecturer showed that the lowering of an artificial sea-bottom by 1 ft. in the air was correctly measured by the apparatus.

Passing on to directional wireless, Mr. Smith pointed out that the three systems available—viz., the single coil turning about its vertical axis, the Robinson system, employing two unequal coils at right angles to one another, and the Bellini-Tosi system in which two cross coils were used with an exploring coil—would all indicate the plane of the source of the radio-signals. Some 40,000 observations taken at 10 stations in different parts of England, however, showed that the bearings thus obtained might be in error by 5 degrees, or even by as much as 60 degrees or more, especially in the evening and over long-distance ranges. Yet it was very important to notice that when the transmission was entirely over the sea, and the distance did not exceed 80 miles, the error would not be more than ± 2 degrees; even with inland transmitting stations, situated not more than 15 miles from the shore, the probable error could be brought down to that limit. Bearings could be determined by three methods. The ship transmitted to two or three receiving stations on shore, fitted, in this country, with Bellini-Tosi apparatus; or the ship could be equipped with a directional receiver; or several single-coil receiver stations on shore were connected to a central station which would communicate the results to the ship. This last-mentioned method had been used with excellent results near Long Island, New York, as was clearly shown by lantern slides exhibited by the lecturer. The





navigating officer, however, preferred to rely upon his own observations, and this could be done by means of the short-wave system of the Marconi Company and by the coil system of directional transmission. In the latter system transmission was made from a suitably-wound coil which was rotated at a constant rate about its vertical axis, emitting a revolving radio-beam at right angles to its plane. The beam, as picked up by the ship's aerial, gave two maxima and two minima in each revolution, the maxima serving to indicate the plane of the transmitting station. The latter also emitted a north signal when the plane of the coil was east-west, and a west signal when the plane was north-south. By counting the number of seconds intervening between the reception of the north signal and the zero intensity of the beam, the rate of rotation being known, the navigating officer could calculate his bearing from the transmitter, and, with two or more transmitting stations, could determine his position. This system, the lecturer concluded, was now being tested at Farnborough with satisfactory results.

* See ENGINEERING, June 13, 1919, page 776, "Listening Under Water."

THE LATE MR. ARTHUR HENRY WILSON.—We regret to have to announce the death, in his 71 styear, of Mr. Arthur Henry Wilson, of Sandridge Park, Totnes. Mr. Wilson had been an associate member of the Institution of Civil Engineers since February, 1879. He studied from January, 1874, to June, 1875, at the Crystal Palace School of Engineering, and served from August, 1875, to March, 1877, as a pupil under Mr. F. E. Townsend, on the Abersychan branch of the London and North Western Railway, on which very heavy work was being carried out at the time. During the remainder of 1877 Mr. Wilson was assistant resident engineer for Mr. Gardner on the same line, and had to superintend and set out station buildings. Later he was appointed engineer on the Batley and Dewsbury line of the Great Northern Railway for Messrs. Baker and Firbank. Mr. Wilson had continued his railway engineering activities until quite recently.

CONDUCTIVITY AND SPECIFIC HEAT OF REFRACTORIES AT HIGH TEMPERATURES.

THE United States Bureau of Mines has resumed the experiments on the conductivity of firebricks which G. R. Greenslade and F. A. Hartgen discontinued in 1922. The published data on this subject are by no means in accord, and it has been recently suggested by Professor E. B. Wilson, of the Massachusetts Institute of Technology, that, quite apart from experimental difficulties, the fundamental law of heat conduction, due to Fournier, might not strictly hold for large temperature gradients. According to Fournier the loss of heat H in calories per second from the area A of a body of thickness l is $H = k(t_1 - t_2)/l$, where t_1 and t_2 indicate the temperature of the two surfaces and k is the conductivity of its body; the question is whether k really remains constant for all values of the gradient $(t_1 - t_2)/l$.

In order to facilitate the experiments Greenslade and Hartgen placed the thermocouples used to determine the surface temperatures, not on the brick under test, but on a surface of permanent conducting plates which could quickly be cemented to the brick and would remain undisturbed when changing samples. The arrangement had its advantages; but 18 thermocouples were required and had to be joined to a Tinsley vernier potentiometer. In their resumed work (Bureau of Mines, Investigation Report, Serial No. 2564), M. D. Hersey and E. W. Butzler dispense with the iron plate and potentiometer observations, and make use of three thermocouples in each layer of brick under test. Two of these couples are cemented into grooves close to the respective surfaces for observation of temperature drop during the conductivity tests, while the third is an interior junction (half-way between the two surfaces) for reference in checking heat-flow measurements and in computing the relative specific heat of successive materials from observations on the rate of heating. The electrical heat units put in are directly determined after a steady state of temperature is reached which may require 48 hours. Each of the two layers of brick fixed on opposite sides of the central heater, is about 12 in. sq. and has the thickness of one brick (about 2 in.); the separate bricks are cemented together and to the adjacent conducting plates by means of brick dust and alundum.

The experiments made with "hytex" building bricks gave the following values for the conductivity k, expressed in calories per second per sq. cm. per degree centigrade for 1 cm. thickness: k at 140 deg., 160 deg., 220 deg. = 0·00275, 0·00288, 0·00292. "Central of Georgia" firebricks gave at 250 deg., 370 deg., 910 deg., k = 0·00193, 0·00187 and 0·00263. The discrepancy at 370 deg. is not explained. The former bricks had a density of 1·80, the latter of 2·14. Referred to calories per gramme per degree centigrade the mean specific heat of the latter bricks was found to be 0·250 near 700 deg. and 0·262 near 900 deg. Questions of the rate of heating or cooling of a body depend both on conductivity and specific heat, and further upon the porosity, grain size, surface condition and other factors, difficult to allow for, which should be studied *in situ*.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—The annual dinner of the Institution of Locomotive Engineers, held at the Engineers' Club, London, on Saturday last, was well attended and successful, the speeches being commendably brief and the musical part of the programme artistic. The chair was taken by Mr. Arthur A. Stamer, the president. The guest of the evening was Mr. R. L. Wedgwood, the manager of the London and North Eastern Railway, who replied for "The Guests." The toast of "The Institution" was proposed in appropriate and humorous terms by Mr. W. H. Patchell, the president of the Institution of Mechanical Engineers.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—The Institution has been fortunate in having two more valuable prizes offered; the first is one of 50*l.* presented by the Humber Company, which the council have decided to offer, for the best paper submitted by anyone whether a member or not, dealing with the points necessary in the design of a car to meet colonial conditions. The paper which is awarded the prize will be read at the joint conference held by the Society of Motor Manufacturers and Traders and the Institution at the British Empire Exhibition at Wembley in June. The paper may deal either with the motor car, the commercial vehicle or vehicles of the track-laying type. The second prize is one of 20*l.* offered annually by the *Automobile Engineer* for the best contribution to the discussion on any paper read by a senior member, while a further prize of books to the value of 5*l.* 5*s.* will be given to the graduate who makes the best contribution to the discussion on any paper read by a senior member. The Institution is now represented on the main committee of the British Engineering Standards Association by Mr. H. G. Burford and Dr. T. Blackwood Murray.

INDUSTRIAL NOTES.

THE coal crisis was referred to in the House of Lords last week, when Lord Gainford stated that the agreement now in dispute was one of the most advantageous in connection with wages that had ever been produced, because under it, whatever the industry earned was shared in by the workers. It was also due to the agreement that during the 30 months it had been in operation, of all the industries of the country, the coal industry had been most progressively developed, not only in regard to output of coal, but also as to the number of men employed. There was no disposition on the part of the miners or the coalowners to allow the present position to drift. The delay in meeting the men had been due largely to many of the miners' leaders having accepted positions in the Government. Sub-committees of the owners and the men were looking into the whole question of the capacity of the industry to pay wages, and their report would be considered. Large numbers of the miners were anxious that there should be no cessation of work, and the owners, on the other hand, were anxious that there should be fair play for the men. The miner's executive refute the statement put forward by Lord Gainsford as the cause of the delay in meeting the men, and place the blame on the owners.

Joint meetings of the owners' and men's representatives to consider the situation were held yesterday.

The Christmas holidays have had the effect of greatly reducing the output of the Welsh collieries, and also the available surplus profits for November and December, compared with the preceding two months, according to the joint audit of the South Wales Coal Trade. The situation allows only 20·95 per cent. on the 1915 wage standard, about 6 per cent. less than for the last ascertainment. Mr. Finlay Gibson, secretary of the Coalowners' Association, states that in order to make up the minimum wage of 28 per cent. on the standard during the ensuing two months the owners will have to sacrifice the whole of their 17 per cent. share of profits and, in addition, 156,000*l.* of their standard profits.

Following upon the increase in dockers' wages, the Mersey Docks and Harbour Board has decided to add 155 per cent. to the charges specified in the schedule of master porters' charges to which an addition of 136 per cent. hitherto applied, and to add 144 per cent. to those charges to which a percentage addition of 125 hitherto applied. On April 1 an increase of 10 per cent. is to be made on harbour rates at present payable on all vessels except steam fishing vessels which come into or go out of the port without increasing dock tonnage rates. The object of this increase is to relieve the Board from an expenditure it has hitherto borne, but which rightly falls upon persons not using the docks but using the harbour and getting the benefits of the expenditure made on the harbour.

The building operatives, having put forward an application for an increase in wages of 2*d.* per hour, the Wages and Conditions Council for the building industry has lately had the matter under consideration, but so far no agreement has been arrived at. Clay workers are also claiming an increase in wages and are threatening a strike which would involve 150,000 brick makers.

The Southampton shipyard engineers are still on strike with a view to enforcing their demand for an immediate advance of 17*s.* 6*d.* per week, and their independent action is causing difficulties to the Federation of Engineering and Shipbuilding Trades, who, as already stated, are claiming an advance of 10*s.* per week. It is now announced that the United Society of Boilermakers and Iron and Steel Shipbuilders, who no longer form part of the Trades Federation, are also claiming an advance of 10*s.* per week.

The cotton dispute referred to in our last issue remains unsettled at the time of going to press. Meetings of representatives of both sides have been held, and a joint conference took place yesterday. In a written reply in Parliament, the Minister of Labour, questioned as to the steps he proposed to take to avert the calamity of all the spinning mills coming to a standstill, said he was sure all the parties fully realised the desirability of avoiding a stoppage which would aggravate the present difficulties with regard to unemployment. He was hopeful that the parties would reach a settlement by themselves. The Cardroom Amalgamation met the Master Spinners' Association yesterday to discuss the situation.

A dispute has arisen among the electricians engaged in laying the cables and leads at the Wembley Exhibition. The dispute is between the Electrical Trades Union and several of the contracting firms who are employing non-union men, or men who are paid less than the London rate of wages.

The question of the railway shopmen's wages on the Great Northern Section of the London and North Eastern Railway, to which we have referred in former issues, has come up afresh. The question, it will be remembered, is one concerning which the National Union of Railwaymen and the craft unions are not in agreement. The Minister of Labour has stated that the Government has decided to institute in this matter, as in all others affecting public needs, a public inquiry in order that the public should know all the facts.

Lord H. Cavendish-Bentinck asked the Prime Minister in Parliament last week whether he would call together representatives of employers and employed with the object of setting up a national industrial conference to formulate an industrial or labour code which would provide for a fair profit to the employers, security, and an adequate standard of life to the workers, and immunity from unnecessary strikes and lock-outs to the general public. Mr. MacDonald, in reply, said it was not clear that any useful purpose would be served by such a conference as was suggested, but if there were any general indication by employers' and workers' organisations that a conference should be called, the Government would be prepared to give the suggestion sympathetic consideration.

Reports are current to the effect that the Kiel shipbuilding yards have locked-out all their workers to the number of about 13,000, following their refusal to work nine hours per day instead of eight. The proposed institution of a nine-hour day is also causing difficulties in other German industrial and commercial concerns.

Speaking last week at the annual meeting of shareholders of the Manchester Ship Canal Company, and dealing with the recent dock strike, the chairman, Mr. W. C. Bacon, said the directors were of opinion, when the advance was first formulated, that an increase was not due in the district. The minimum rate of wages earned by dock workers at Manchester was 125 per cent. over pre-war rates, therefore much above the cost-of-living figure. Work was plentiful, and the casual workers were employed on the average five days per week, counting work done in overtime hours; sometimes there was a shortage of men. The company had made proposals to the men and union leaders to consider a scheme of working night shifts at reasonable rates, thus securing better dispatch to vessels than could now be done with the port limited merely to three hours' overtime per night from Monday to Friday, equalling in the total only 15 extra hours. Such a scheme would gain for the port a good reputation and would draw more trade to the canal.

Messrs. Royle's, Limited, Irlam, near Manchester, who have made a speciality of heat transmission plant, have worked for some years a profit-sharing scheme for their staff and works employees, and on February 28 they paid them a sum of money equal to 8 per cent. on the salaries and wages earned for the year 1923. In addition to this, they paid wages for seven days summer holidays to the works people. This arrangement seems to have given very satisfactory results as regards amicable relations throughout the whole establishment.

COURSES FOR TEACHERS IN TECHNICAL AND EVENING SCHOOLS.—The Board of Education are making arrangements for short courses of instruction for teachers in technical and evening schools, to be held in the summer, namely, engineering science at Oxford and Birmingham; electrical engineering also at Oxford and Birmingham; building subjects in London; commercial subjects at Cambridge. Teachers who desire to attend any of these courses should make application to the Board of Education, on form 106c.U. as soon as possible, and not later than the 31st inst.

THE LATE MR. FRANK VINCENT ELSDEN.—We regret to have to record the death, which occurred in London on February 29, of Mr. Frank Vincent Elsden, of the Indian Government Service. Mr. Elsden was born in January, 1881. He was educated privately and at the University School, Hastings. He then received scientific training at the Brighton Municipal School of Science, the Central Technical College, and under Messrs. Druitt Halpin and Allan Greenwell. Later, from 1901 to 1906, Mr. Elsden studied civil engineering under Professor Unwin. He acted as assistant to Mr. A. Greenwell, the consulting engineer of the Equi Valley Marble Company, Limited, near Carrara, Italy, and very early in his career he proceeded to India, where he carried out a large amount of canal work. Mr. Elsden became a student member of the Institution of Civil Engineers in 1906 and was elected a full member in 1920.

THE "SHELL" KERBSIDE PETROL PUMP.

SINCE the introduction of kerbside pumps for the supply of petrol to motor vehicles there has been much discussion both as regards the quality and quantity of the spirit delivered from these appliances. Rightly or wrongly, they have been regarded with considerable suspicion from these points of view, although their great convenience, both to the motoring public and to the garage proprietor, has never been in question. To allay the suspicion which still exists, although perhaps to a lesser extent than was formerly the case, it is obviously necessary to provide means whereby the purchaser of petrol supplied through one of these pumps can satisfy himself that he is obtaining full measure and that the quality of the petrol is that for which he pays. Only an unscrupulous dealer would attempt to evade such provisions, but the vendor would naturally object to supplying a quantity materially in excess of that paid for by the purchaser. In practice, the problem of designing a pump which will be equitable to both parties under all conditions, and at the same time will be reliable and reasonably rapid in operation, is less simple than might appear at first sight, but it seems to have been solved in a very satisfactory manner in the pump designed by Messrs. Shell-Mex, Limited, of Shell-corner, Kingsway, W.C.2, so that the description of the pump which we now propose to give should be of interest to engineers, as well as to users of private and commercial motor vehicles.

The general arrangement of the pump is illustrated in Figs. 1 and 2 on page 302, and its appearance, when opened for use, is shown in Fig. 8 on page 303. Altogether about 2,500 of these pumps have been installed in different parts of the country, the earlier ones functioning on a slightly different principle, but these are gradually being converted to the type illustrated. The pumps are manufactured by British engineering firms of good standing, and a considerable number of them have been made at the Erith Works of Messrs. Vickers, Limited, where we recently had an opportunity of inspecting them in the course of construction. The pumps are made in two sizes, which deliver the petrol in units of half-a-gallon and a full gallon, respectively; no fraction of these units can be supplied, but any multiple of them can, of course, be delivered. The half-gallon size is most commonly employed and as the designs of both sizes are generally similar, except as to the volume of the measuring vessels, we propose to confine our description to the smaller pump.

As will be seen on reference to the illustrations, the apparatus is enclosed in a wrought-iron plate casing, bent so as to form a cylindrical column 1 ft. 4 in. in diameter and provided with a circular sliding door fitted with a snap lock. The door is carried on a complete ring at the top, running on roller bearings so that it can be moved easily. The arrangement is obviously much neater than a hinged door opening back in the ordinary way. The column, as shown, has a cast-iron octagonal base and a cast-iron cap, the latter surmounted by a glass globe which is electrically illuminated at night. Louvre ventilators, fitted with Davy safety gauze, are formed in the base casting to permit the escape of vapour, which might otherwise collect when the casing is closed. The petrol is stored in an underground cylindrical tank constructed of ¼-in. mild-steel plates with welded joints, and shot blasted both internally and externally to remove all traces of mill scale. The tanks, which are coated externally with a rust-preventive composition, are made in three standard sizes holding 300, 500 and 1,000 gallons, respectively, but tanks of any shape and size can, of course, be supplied to meet special requirements. The filling connections and the pipe connections to the pump are all made through a manhole cover on the tank and are accessible through a cast-iron cover on the ground level, the cover being of sufficient strength to support vehicular traffic. The petrol is supplied to the underground tank in bulk from the tank of a motor lorry and, in connection with the filling arrangements, two methods of protecting the consumer as to quality, or grade, are employed. Either the driver of the lorry will retain the key after locking the filling pipe cap in position, or will seal it with a standard seal. A certificate as to quality is supplied with each delivery and fixed in a prominent position on the pump.

Before describing the apparatus in detail, we may first explain it generally by mentioning that the petrol is raised from the underground tank by a hand-operated, semi-rotary pump and delivered into one or the other of two measuring vessels, or containers, through a four-way plug cock. When one of the containers is filled, the fact is indicated by the overflow of petrol through a sight glass, and the four-way plug cock is then reversed so that the other container is put into communication with the pump. By the same movement, the filled container is simultaneously opened to discharge through a port in the same plug cock in connection with a flexible hose through which the petrol

THE "SHELL" KERBSIDE PETROL PUMP.

CONSTRUCTED BY MESSRS. VICKERS, LIMITED, ENGINEERS, ERITH, KENT.

Fig. 1.

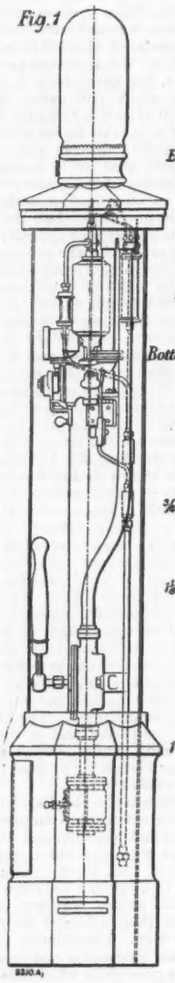
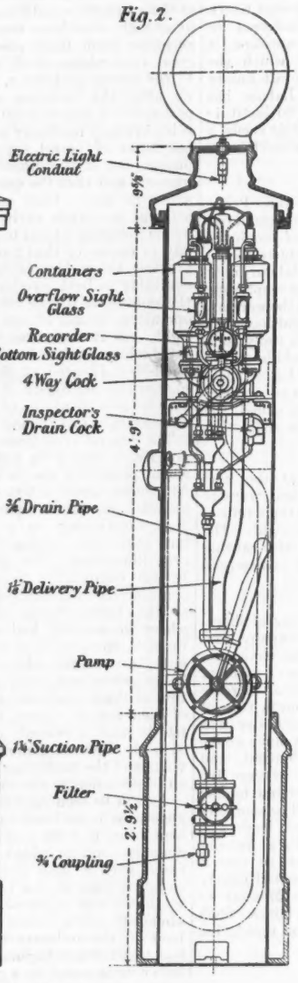


Fig. 2.



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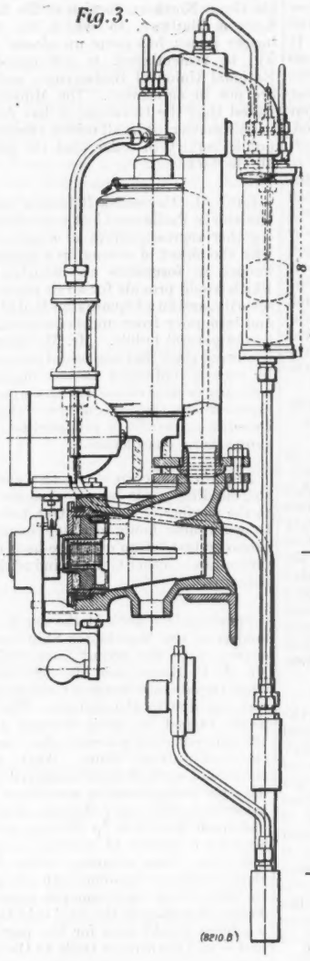


Fig. 4.

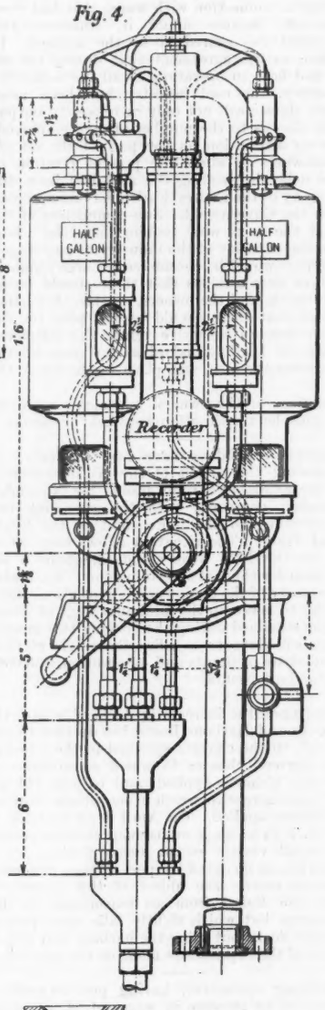


Fig. 5.

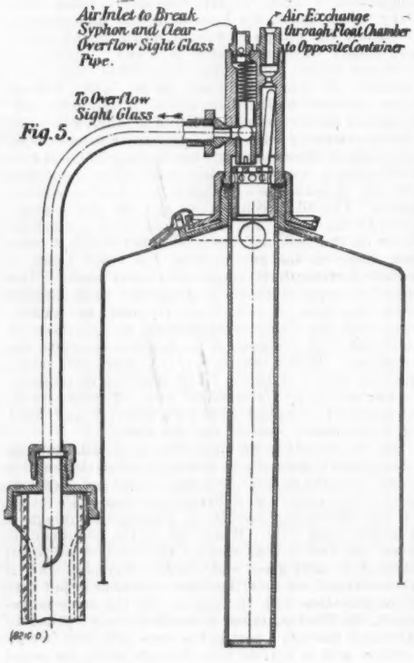

Air Inlet to Break Syphon and Clear Overflow Sight Glass Pipe.
Air Exchange through Float Chamber to Opposite Container
To Overflow Sight Glass

Fig. 6.

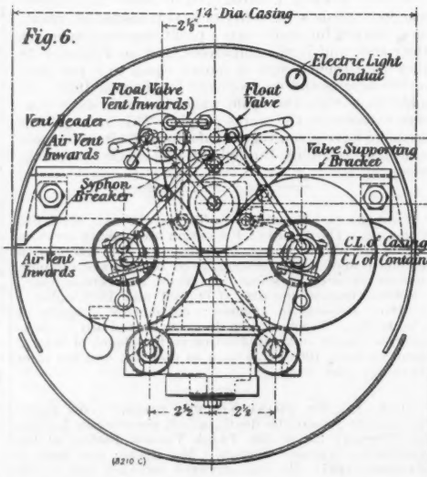
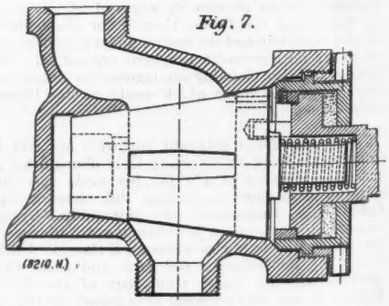


Fig. 7.



runs into the tank of the customer's car. While the first-mentioned container is emptying, the second is filling, and, when filled, the plug cock is again reversed. By alternately filling and emptying the two containers in this way, the delivery of petrol to the car is practically continuous, but it should be mentioned that the delivery is greatly expedited by the fact that the two containers are interconnected at the tops so that the air displaced as one is filled forces out the petrol from the other. In actual use, the half-gallon size, to which we are referring, can supply 10 gallons of petrol per minute. From the customers' point of view it is, of course, necessary to know that the delivering container is completely emptied each time the plug cock is put over, and, for this reason, a sight glass is fitted at the bottom of each container. The fact that the surface of the petrol sinks to the bottom of the glass indicates that the container has been emptied, and by observing these glasses, in conjunction with the overflow sightglasses, the customer can satisfy himself as to the measure supplied. The two overflow sight glasses and the sight-glass at the bottom of one of the containers can be seen in the photographic illustration, Fig. 8, on the opposite page. This figure also shows the counter which is operated from the handle of the plug cock to register the total quantity supplied from the pump and also the quantity supplied to each individual

THE "SHELL" KERBSIDE PETROL PUMP.

CONSTRUCTED BY MESSRS. VICKERS, LIMITED, ENGINEERS, ERITH, KENT.

FIG. 8.

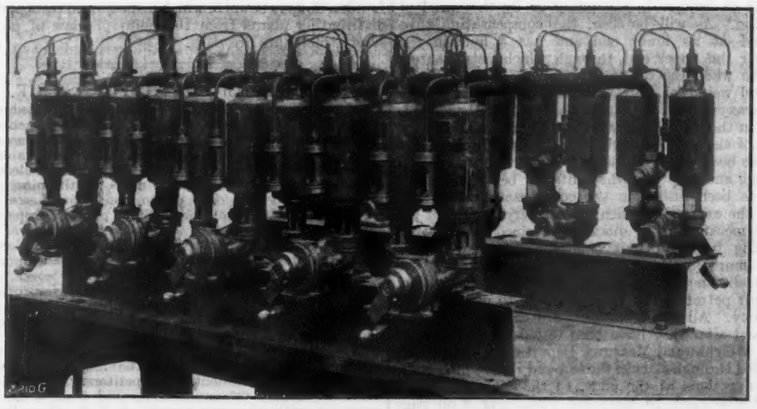


FIG. 9.

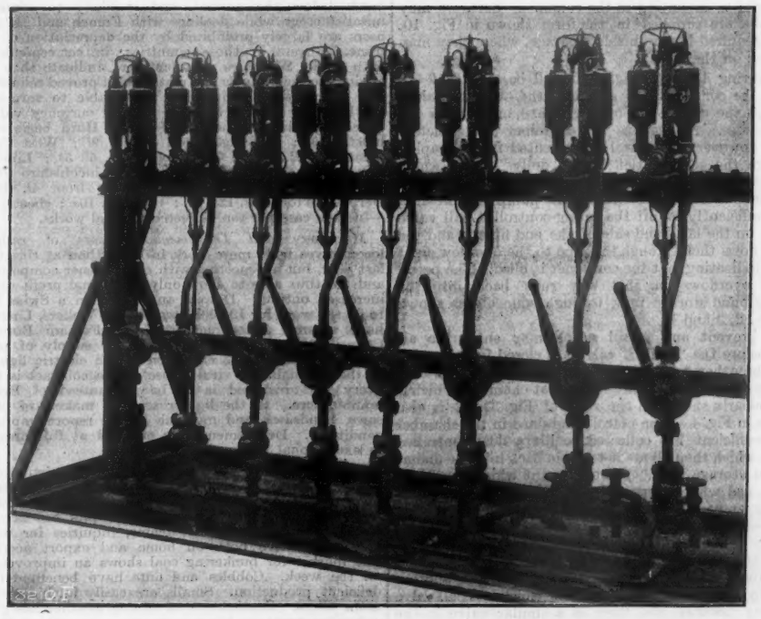


FIG. 10.

customer; no petrol can be taken from the pump without the amount being registered by the counter. The figure indicating the individual quantities supplied can be set to zero each time the pump is used without affecting the total indicator. It should also be mentioned that a bell rings each time the handle of the plug cock is turned, thus giving an audible notification of the quantity delivered.

The general arrangement of the components of the pump is clearly shown in Figs. 1 and 2, while the essential parts are illustrated in greater detail in Figs. 3, 4 and 6. The semi-rotary pump, which raises the petrol from the storage tank and delivers it to the containers, is connected to the tank by 1¼ in. galvanised iron piping in which is fitted a fine wire-gauze filter to retain any foreign matter. The filter is designed and arranged so that it can be easily and rapidly cleaned at any time, access being obtained to it through a removable cover in the base casting. The filter gauzes are 3-ply laminations of special construction to check the passage of all impurities. They are mounted on a cage, which can be readily withdrawn for cleaning by unscrewing a single set screw. At the bottom of the suction pipe, a foot valve is provided, and also a strainer box, the object of which is to prevent any water which may be present in the bottom of the tank from being drawn up by the pump. The delivery pipe, which is of solid-drawn copper 1¼ in. in diameter, is taken up above the level of the containers, as is most clearly shown in Fig. 4, and led down to the plug cock through a cast gun-metal "U" connection at the top.

The design of the plug cock is illustrated in Fig. 3, which also shows the form of the metal-to-metal joint union used for the connection of the delivery pipe. The delivery hose is attached to a screwed connection at the bottom of the body of the cock, shown in Fig. 3, while connections from the sides of the body lead to the bottom of each of the containers, as will be understood on reference to Fig. 4. The construction of the cock is more clearly shown in the section reproduced in Fig. 7. From this illustration it will be seen that holes are drilled through the plug so as to connect the spaces at the ends with the delivery port, the object of these holes being to utilise the hydraulic pressure obtained when pumping to retain the plug on its seating. As shown by the drawing, the plug is separated from the operating handle, so that there is no possibility of moving the plug longitudinally when the handle is turned. The rotary motion of the handle, however, is transmitted to the plug through two pins fixed on a flange formed on the end of the handle spindle and fitting into corresponding holes in the end of the plug; one of the pins is clearly shown in Fig. 7. A light helical spring, which surrounds the stem of the plug and is enclosed in a recess bored in the end of the spindle, is provided to retain the plug in position while it is being reversed or when the hydraulic pressure is released. A petrol-tight joint round the end of the spindle is made by means of a washer of compressed granulated cork, the washer being thoroughly impregnated with melted yellow soap before it is placed in position. We may add that cocks made to this design are extremely easy to operate and have been found to remain petrol-tight for long periods without any appreciable wear.

The containers are of drawn brass and are usually made in two parts with a circumferential joint midway between the ends, the joints being made by sweating to an inner strengthening ring. Fig. 5, which is a section through the upper end of one of the containers, shows the connection to the overflow sight glass and the connection permitting air to pass to and from the other container. An interesting detail, also shown in Fig. 5, is the central compensating tube, by means of which the container is calibrated within the necessarily fine limits imposed by this particular service. It may be remarked here that, in accordance with the requirements of the Weights and Measures Department, any error in the quantity

delivered must be in the customer's favour, and must not exceed 2 drams per gallon, but the error in practice, we are informed, is much less than this amount, and is, in fact, practically negligible. Moreover, once this degree of accuracy has been secured it is maintained indefinitely, being unaffected by wear or leakage in the pump or by the speed of operation. As will be seen, the compensating tube is closed at its lower end and has a hole in the side near the upper end, through which petrol enters the tube when the container is filled. This quantity of petrol would, of course, be retained when the container was emptied, but for the fact that another hole is drilled in the side of the tube at a lower level, allowing a part of the petrol in the tube to run out with that from the body of the container. Calibration is effected by filling and emptying the container before the lower hole has been drilled in the compensating tube and noting the extent by which the delivery is short of the correct measure. The quantity retained in the compensating tube per unit length being known, it is then a simple matter to drill a hole in the tube at the correct distance from the closed end to allow just sufficient petrol to run from the tube to make up the deficiency. All the containers are calibrated in this way, and after they have been tested by an inspector of the Weights and Measures Department, sealed tags are fitted through slots in the screwed rings which make the connections at the ends, so that the calibration cannot afterwards be tampered with. Fig. 9 on page 303 shows a batch of containers which have been calibrated and are ready for testing and sealing, while in Fig. 10 are shown a number of completed sets under test prior to mounting in the columns. Sets, we may mention, are supplied in the form shown in Fig. 10, when required for use inside a garage, where they may be fixed on the wall.

Referring again to Fig. 5, it will be seen that the air in the container can pass into the other container through the connection on the right-hand side as the petrol rises. As soon as the container is completely filled, however, the petrol is prevented from escaping through the same outlet by a "dolly" valve which is carried up with the petrol and so closes the opening. As more petrol is delivered from the pump, the pressure rises sufficiently to lift the spring-controlled ball valve shown on the left-hand side of the end fitting, and the petrol flows then through the pipe to the overflow sight glass, indicating that the container is filled. The petrol which overflows in this way runs back into the underground storage tank through connections shown in Figs. 2, 3 and 4.

To prevent any petrol which may enter the air pipe before the "dolly" valve has closed from passing into the other container, the air pipes from both containers are connected through a float chamber, which is most clearly shown on the right of Fig. 3, but is also visible in Fig. 4. The petrol is retained in the chamber until sufficient has collected to lift a float-controlled valve, which then allows it to drain back into the underground storage tank. Another point which should be mentioned while referring to the float chamber is that the upper part of it is connected through an inverted "U"-shaped pipe to a part described as a vent header in Fig. 6, and also shown in Fig. 4 near the top of the illustration, immediately to the right of the left-hand container. Connected to the vent header is another inverted "U"-tube, in the end of which is a ball valve opening inwards, and there is a similar valve in the pipe connecting the vent header to the float chamber. By means of these valves, air can enter the system if the internal pressure should fall below that of the atmosphere, and this enables petrol to flow by gravity from the containers to the flexible delivery pipe if pumping should be stopped with one of the containers partly filled. An anti-syphon pipe connected between the vent header and the highest point of the delivery pipe between the hand pump and plug cock, is provided, as shown in Figs. 3, 4 and 6, to prevent the petrol from running back to the tank when pumping ceases. The only other connection which need be referred to is the one which gives a direct communication between the two overflow sight-glasses, this being provided to admit air into the overflow pipe and quickly clear any petrol it may contain when the ball valve closes. The connection for this purpose is made above the spring-controlled ball valve, as shown in Fig. 5, and the pipe joining corresponding parts of the two container fittings can be seen at the top of Fig. 4.

The hose through which the petrol is delivered to the customer's car is 9 ft. in length and 1¼ in. in inside diameter. It has a petrol-resisting lining and is armoured internally and externally, while a strong braiding covers the whole. The free end is provided with a quick-acting plug cock having a long tapered copper nozzle, as shown in Fig. 8. The end of the nozzle is small enough to deliver petrol into the tanks of motor cycles, and a longitudinal indentation is formed in the side to permit the escape of air displaced from the tank as the petrol enters. The hose and nozzle fit easily inside the casing when the pump is not in use.

In conclusion, we may mention that the pump has been passed by the Standards Department of the Board of Trade with regard to accuracy of measurement, and also by the Public Control Department of the London County Council, which inspects and tests petrol-distributing plants from the point of view of public safety, including fire risks.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Despite reports of slightly increased confidence among buyers of steel products and engineering requisites, the market for raw and semi-finished materials is distinctly dull. Except where transport and electrification contracts are concerned, users for the most part are content to rely on hand-to-mouth purchases and to await the advent of more definite pointers respecting the labour factor before committing themselves far forward at current rates. Scrap is a shade easier for most qualities, though heavy wrought iron commands 5*l.* 12*s.* 6*d.* per ton delivered at Sheffield works, and, there is an active call for cast-iron scrap for foundry use round about 5*l.* 5*s.* per ton. Deliveries of hematites for use in manufacture of special steels are maintained at a fairly high level to this district, though here also forward buying is sluggish. Makers of crude steels are moderately active despite the increased pressure reported from Continental competitors. Prices, however, are largely unremunerative, and tend to become more so with the rising cost of fuel. Open-hearth production shows an expansion due to the putting into commission of two more furnaces damped out during the Christmas stoppage. Business in special steels is much below the normal, and is likely to continue unsatisfactory while dealings with French and Belgian users are largely prohibited by the depreciation of the franc. Buyers in those countries, in correspondence with South Yorkshire manufacturers, indicate they are anxious to secure tools and materials of proved reliability and guaranteed quality, but are unable to surmount the huge obstacle of the difference in currency values. Official quotations stand as follow: Hard basic steel billets, 10*l.*; soft basic steel billets, 9*l.*; West Coast hematites, 6*l.*; East Coast hematites, 5*l.* 5*s.*; Lincolnshire No. 3 foundry iron, 4*l.* 16*s.*; Lincolnshire forge, 4*l.* 14*s.*; Derbyshire No. 3 foundry iron, 4*l.* 15*s.*; Derbyshire forge, 4*l.* 12*s.* 6*d.*; bars, 12*l.* 10*s.*; sheets, 15*l.*—in each case per ton delivered at local works.

Machinery and Implements.—Makers of railway locomotives have more work in hand than at this time last year, but are meeting with even keener competition and are thus able to show only a nominal profit on an increased output. Despite an offer from a Swiss firm to do the work for 12,000*l.* less, Messrs. Vickers, Limited, have secured a contract from the Fulham Borough Council, valued at 123,000*l.*, for the supply of plant and materials for the extension of the electric lighting of the borough. A vital clause of the contract is that every part installed is to be guaranteed of British manufacture. In the lighter sections makers of hack-saws, bandsaws, and machine knives report improved conditions. Departments are engaged at full pressure in exceptional cases.

South Yorkshire Coal Trade.—Supplies of virtually all classes of fuel fall below current requirements. Prices in consequence are generally firm, with an upward tendency. Irregular working at the pits has brought about a shortage in best steams, inquiries for which are more active both on home and export account. The market for bunkering coal shows an improvement on the week. Cobbles and nuts have benefited from deficient production. Smalls are easily fetching maximum prices. Continuance of wintry weather has given a further spurt to house-coal purchases. Quotations: Best handpicked branch, 35*s.* to 36*s.*; Barnsley best silkstone, 30*s.* 6*d.* to 32*s.*; Derbyshire best brights, 30*s.* to 32*s.*; Derbyshire best house coal, 26*s.* to 27*s.*; Derbyshire best large nuts, 24*s.* 6*d.* to 25*s.* 6*d.*; Derbyshire best small nuts, 18*s.* 6*d.* to 20*s.* 6*d.*; Yorkshire hards, 25*s.* to 27*s.*; Derbyshire hards, 24*s.* to 25*s.*; rough slacks, 12*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 13*s.*; smalls, 7*s.* 6*d.* to 9*s.* 6*d.*

THE LATE MR. DAVID HOME MORTON.—The death occurred, on Thursday, February 28, at Watford, of Mr. David Home Morton, who carried out the mechanical engineering work in connection with the Glasgow Subway and the Glasgow Main Drainage Scheme. He was born in 1849, and served his apprenticeship in the millwright shop of Mr. John Wilson, of Carluke, and after a period as a draughtsman, with Messrs. A. & W. Smith and Co. and Messrs. Andrew Barclay and Son, he went to Fairfield Shipbuilding and Engineering Company as leading draughtsman. Management experience followed in the works of Messrs. Dick and Stevenson, of Airdrie, and at the Hammersmith Ironworks, after which Mr. Home Morton became chief engineer to Messrs. Tangyes, of Birmingham, and completely re-designed their works. After he returned to Scotland, he was responsible for the introduction of the cable system of locomotion in the Glasgow Subway for Messrs. Simpson and Wilson, of Glasgow. Mr. Home Morton was a member of the Institution of Civil Engineers and received the Telford Premium for a paper on "Glasgow Main Drainage: Mechanical Equipment of the Western Works and of the Kinning Park Pumping Station," in which he described the mechanical engineering work for which he was responsible.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business is extremely quiet, and the tone of the market is very cheerless. Cleveland pig iron is plentiful and slow of sale, with the result that values are still falling and are declared to now be well under cost of production, so that unless a change for the better speedily occurs preparation for the damping down or blowing out of furnaces may be looked for. No. 1 is obtainable at 95*s.* 6*d.*; No. 3 g.m.b. is on sale at 93*s.*; No. 4 foundry is offered at 92*s.*; and No. 4 forge at 91*s.*—all f.o.t. makers' works and f.o.b. Tees.

Hematite.—A hematite furnace going out for repairs somewhat strengthens the hands of producers of that commodity, most of whom have still a little work on hand and adhere to 101*s.* for Nos. 1, 2 and 3; but buyers are disinclined to pay more than 100*s.* No. 1 is quoted 1*s.* above mixed numbers.

Blast Furnace Coke.—Blast furnace coke is rather firmer. Durham good average kinds are 31*s.* to 32*s.* 6*d.* delivered here.

Foreign Ore.—Foreign ore is deadly dull, but freights continue high, and market rates remain on the basis of best rubio at 24*s.* c.i.f. Tees.

Manufactured Iron and Steel.—The manufactured iron and steel industries present no new features of moment. The tonnage output is heavy, but new work is scarce. Competition for export trade is keen, and prices are matter of negotiation, but home quotations remain: Common iron bars, 12*l.*; iron rivets, 14*l.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*.; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 5*s.*; steel angles and joists, 10*l.*; heavy sections of steel rails, 9*l.*; fish plates, 13*l.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 18*l.* 15*s.*

Shipments of Iron and Steel.—February shipments of iron and steel from the Tees—including 1,985 tons of pig iron cleared at Skinningrove—totalled 78,670 tons, of which 16,471 tons were pig iron, 2,730 tons manufactured iron, and 59,469 tons steel. Of the pig iron sent from the Tees, 2,755 tons went coastwise and 11,731 tons went abroad; of the manufactured iron despatched 207 tons went coastwise, and 2,523 tons went abroad; and of the steel shipped, 6,806 tons went coastwise and 52,663 tons went abroad. America was the largest buyer of pig iron, taking 3,925 tons, whilst Belgium received 2,009 tons; Scotland, 1,990 tons; France, 1,450 tons; and Germany, 1,120 tons. India and Egypt were the best customers for manufactured iron, the former receiving 883 tons and the latter 873 tons. India, with an import of 21,191 tons, was the heaviest purchaser of steel, other principal buyers being Egypt, 7,140 tons: New South Wales, 3,815 tons; Natal, 3,003 tons; Ceylon, 2,940 tons; and Victoria, Japan, South Australia, the Straits Settlement, Cape of Good Hope, the Argentine and Chile each over 1,000 tons.

Imports of Iron and Steel.—Statistics issued this week give the iron and steel brought to the Tees from Holland, Belgium, France, Norway, Sweden, Germany and coastwise for the four months ending February 29 last as compared with the same months a year ago, and the corresponding pre-war period of 1913–14. For the months just ended imports of pig iron were 6,126 tons as against 2,436 tons a year ago, and 54 tons in the pre-war period; crude sheet bars, billets, blooms and slabs were 16,181 tons as against 21,720 tons a year ago and 14,309 tons in the pre-war period; and plates, bars, angles, rails, sheets and joists were 4,456 tons as against 4,210 tons a year ago, and 7,906 tons in the pre-war period.

THE LATE MR. OLIVER CLAUDE ROBSON.—We regret to have to announce the death, which occurred on the 3rd inst., at 87, Victoria-street, S.W.1, of Mr. Oliver Claude Robson, who was for nearly 50 years engineer to the Willesden District Council. Mr. Robson was born in June, 1849, and after having been articled in 1864 to Mr. Lewis Angell, he was engaged on various engineering and municipal works, including the Portsmouth main drainage. From 1867 to 1875 he was assistant surveyor to the West Ham Local Board. In the latter year Mr. Robson was appointed engineer and surveyor to the Willesden District Council, a position which he held since and in which he carried out a large amount of drainage, sewage treatment and other works. He was elected a member of the Institution of Civil Engineers in 1895.

SOFTENING OF GREY CAST IRON BY HEAT.—Having in previous experiments found that the pearlite in grey cast iron can be destroyed and converted into ferrite by heating for 24 hours up to 600 deg. C. or for three hours up to 650 deg. C., Dr. E. Schüz (*Stahl und Eisen*, January 31) conducts further experiments at 800 deg., the temperature at which the reheating furnaces of his works are generally kept by the lignite fuel used and which is above the Ac_1 point. He finds that thin-walled small boxes need only be heated for a short time to 800 deg. They should then be cooled slowly to 600 deg. and be taken out of the furnace, which can thus be charged three times a day. Whether the high temperature is maintained for minutes or hours does not matter; the essential thing is the cooling through the Ar_1 range which, for pieces of 3 mm. wall-thickness, should not exceed a rate of 3 deg. C. per minute.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—A quiet tone continues to prevail in the Scottish steel trade, and there is not much life showing. The general demand is not heavy and only a limited amount of fresh booking is taking place; buyers on the whole are acting with great caution. The fixing of a few more shipbuilding orders has tended to brighten the outlook for ship plates and sections. Constructional material is also the turn better as there are more inquiries in the market from consumers. Makers of black sheets are still well employed on old contracts and new business is showing up better. The export trade fails to respond to any inducements held out by sellers, with the result that little is being done in shipping business. Home prices keep steady and the current quotations are as follow:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade—In the West of Scotland malleable-iron trade little progress falls to be reported. Old contracts are mostly managing to keep works moving at the present time, as consumers are not buying to any extent and are holding off pending an improvement in general trade. In the steel re-rolling branches a fair amount of work is being done. No alteration has been made in prices, and "crown" bars are still quoted at 12*l.* 10*s.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—There has been no change for the better in the state of the Scottish pig-iron trade over the week and slackness in demand is all too general. Steady deliveries of hematite are being made to the steel works, but foundry grades of iron are not moving satisfactorily. Good stocks are held by most makers and the reduction in production will not be much felt. Current quotations are as follow:—Hematite, 5*l.* 7*s.* 6*d.* per ton, delivered at the steel works; foundry iron, No. 1, 5*l.* 6*s.* 3*d.* per ton, and No. 3, 5*l.* 1*s.* 3*d.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, March 1, only amounted to 671 tons. Of the total 463 tons went overseas, and 208 tons went coastwise. For the corresponding week of last year 1,268 tons went to foreign destinations and 94 tons coastwise, making a total shipment of 1,362 tons.

Scottish Shipbuilding.—The shipbuilding returns for the past month give some idea of the state of the industry at the present time, and although there are a number of new vessels on order not much headway has yet been made with them. The figures for February are as follow:—

	Vessels.	Tons.
The Clyde	13	10,607
The Forth	1	2,656
The Tay	1	1,000
The Dee and Moray Firth ...	2	870
Total	17	15,133

The above totals are far from satisfactory, particularly those for the Clyde, which is the poorest February return for many years and is much below the average. It compares very badly with the year 1921, when the February output was over 82,000 tons. The Clyde total for the year to date is now 22 vessels of 47,524 tons. New contracts are still very difficult to secure and several causes are advanced as being the reason of this. Freights have much to do with the matter, but the cost of construction is perhaps the main factor. In this connection the demand of the shipyard workers for an advance of 10*s.* per week has to be taken into account when quoting for new work, and even without the addition the shipowners consider that the prices named are not economic from their point of view. The actual amount of work on hand is fair, and when a start is made in the construction of vessels on order a goodly number of men will be absorbed.

CANADIAN COAL IMPORTS IN 1923.—According to statistics compiled by the Canadian Dominion Bureau of Statistics, and referred to in the Board of Trade Journal, the coal imports from the United States during the twelve months ended December 31, 1923, included 5,165,382 tons of anthracite, valued at 46,457,962 dols., and 15,822,240 tons of bituminous coal, valued at 49,899,099 dols. Coal imports from the United Kingdom during the same period included 261,675 tons of anthracite valued at 2,667,982 dols., and 310,895 tons of bituminous coal valued at 1,312,821 dols.

NEW GLASGOW DOCKS.—The extension of the dock accommodation on the Clyde, to meet the increasing requirements of Glasgow trade, has been arranged for by the ultimate provision of five new basins at Shieldhall. Of these the first is to be constructed immediately, and at the last meeting of the Committee of Management of the Clyde Navigation Trust, the tender of 721,716*l.* for the construction of the quay walls of this basin, submitted by Messrs. Shanks and McEwan, was accepted. This dock will have a water area of 40½ acres, a depth at low water of 32 ft., and a width of 350 ft. The dredging of the basin will be undertaken by the Trust with their own plant, and, as the work progresses, contracts are to be placed for the erection of sheds and the provision of equipment. This is the beginning of an enterprise which will add, when entirely completed, 7 miles of quayage to the harbour. Large graving docks are included in the scheme.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—For spot and prompt loading the coal market is weak because of an insufficient supply of shipping to meet the requirements of exporters, with the result that colliery owners are ready to make concessions to buyers who can help them to keep the pits working regularly. The shortage in tonnage has been caused by the diversion of shipping during the dockers' strike, but the position is rapidly improving, thanks to active chartering at advancing freights. For shipment ahead salesmen are firmly demanding 30*s.* for best Admiralty large coals and 19*s.* for best steam smalls, and buyers, in view of the possibility of a coal strike in April, are showing a disposition to cover their requirements, notwithstanding that the freight to Genoa has advanced from an average of 9*s.* 1*d.* in January to 13*s.* 3*d.* and 13*s.* 6*d.* for small boats and from 12*s.* 5*d.* to 14*s.* 6*d.* and 15*s.* for the River Plate, while the Rouen rate has also jumped from an average of 4*s.* 11*d.* to 5*s.* 6*d.* and 6*s.* The miners' wages in this and next month are to remain at the minimum of 28 per cent. on the 1915 standard rates. The certificate of the joint accountants for the South Wales Coalfield for the months of November and December shows that after allowing for standard wages, other costs and standard profits, there is available a surplus of 653,089*l.*, compared with 959,933*l.* under the previous audit. The surplus is only sufficient to pay a general wage rate of 20·95 per cent. on the 1915 standard rates, against 26·93 per cent. in September and October. In order to pay the minimum of 28 per cent. the owners are compelled to sacrifice 156,000*l.* of their standard profits. The principal cause of the reduction in the surplus was the falling off in output caused by holidays, Christmas being responsible for a loss of 500,000 tons combined with an increase in the cost of production. The increase in the wages cost was 2½*d.* per ton, and in the other costs 3*d.* per ton or 5½*d.* per ton, while the average pithead price of all the coal produced amounted to 19*s.* 7½*d.* per ton in November and December, compared with 19*s.* 11½*d.* per ton in September and October.

Mountstuart Dry Docks and Shearman's, Limited.—Mr. Frank Shearman, managing director of the Mountstuart Dry Docks and Shearman's, Limited, has decided to surrender 150,070 of his 1*l.* deferred ordinary shares so as to reduce the capital of the company to a figure consistent with present-day values. At an extraordinary general meeting of shareholders to-day a resolution was adopted that the capital of the company should be reduced from 875,070*l.* to 725,000*l.* by the cancellation of 150,070 deferred ordinary shares. The issued share capital will then consist of 200,000*l.* 6 per cent. preferred ordinary shares of 1*l.* each and 525,000*l.* deferred ordinary shares of 1*l.* each.

Iron and Steel Trade.—Exports of iron and steel goods from South Wales last week amounted to only 9,632 tons, the smallest quantity shipped in any similar period so far this year. Shipments of tinplates and terneplates amounted to 3,792 tons, compared with 10,754 tons in the previous week; blackplates and sheets to 4,044 tons, against 1,849 tons; galvanised sheets to 704 tons, against 3,846 tons; and other iron and steel goods to 1,092 tons, against 1,509 tons.

ABERDEEN UNIVERSITY.—It is announced that Dr. William Blackadder, for many years a member of the staff of the Royal Technical College, Glasgow, has been appointed to the newly-created Jackson Chair of Engineering in Aberdeen University.

JUNIOR INSTITUTION OF ENGINEERS.—On Friday, February 29, Mr. W. A. Rhind delivered a lecturette on "The Manufacture of the Incandescent Electric Lamp." Mr. Rhind described the preparation of the tungsten filament and other components of the electric lamp and gave a full account of the method of their assembly in the vacuum lamp as well as in the ordinary and the pipless gas-filled lamps. Particulars of the pumping and gas-filling operations were entered into. The various shapes of filaments were distinguished, and the lecturer concluded with a short note on the manufacture of carbon filaments. An interesting discussion followed, in the course of which the lecturer explained the advantages of the pipless lamp, and answered questions relating to the ageing and blackening of lamps, and also questions about neon lamps and tubes.

THE LATE MR. CHARLES RENNOLDSON.—It is with great regret that we have to record the death, which occurred on the 1st inst, in his 67th year, of Mr. Charles Rennoldson, J.P., the head of the firm of Charles Rennoldson, & Co., Limited, Lawe Shipyard, South Shields. He was a son of Mr. J. P. Rennoldson and a grandson of Mr. George Rennoldson, who founded, about 125 years ago, the works in Wapping-street, South Shields, now known under the title of J. P. Rennoldson and Sons, Limited, engineers and shipbuilders, the principal being a brother of the deceased. Mr. C. Rennoldson served his apprenticeship as an engineering and shipbuilding draughtsman under Mr. Clanton, a naval architect, afterwards entering the Wapping-street works, of which on the death of his father, in 1878, he became the owner together with his brother, the late Alderman J. M. Rennoldson. The partnership was dissolved in 1913, when the deceased started on his own account at the Lawe. Mr. C. Rennoldson was held in high esteem by all his employees. According to his wish, he was buried at sea.

NOTICES OF MEETINGS.

THE INSTITUTE OF METALS: SCOTTISH LOCAL SECTION.—Monday, March 10, at 7.30 p.m., in the rooms of the Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow. Annual General Meeting: address by G. B. Brook, F.I.C., F.C.S., on "The Romance of Aluminium."

THE ROYAL SOCIETY OF ARTS.—Monday, March 10, at 8 p.m., at John-street, Adelphi, W.C.2. Cantor Lecture: "A Study of the Destructive Distillation of Coal," by Edward Victor Evans, O.B.E., F.I.C. (Lecture III). Wednesday, March 12, at 8 p.m. Ordinary meeting. "Personal Recollections of some Notable Scientific Men," by Alan A. Campbell Swinton, F.R.S. Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., will preside.

INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, March 11, at the Royal Society of Arts, John-street, Adelphi, at 5.30 p.m., when the president, Herbert Barringer, M.I.Mech.E., M.I.N.A., will give an address.

THE INSTITUTION OF MARINE ENGINEERS.—Tuesday, March 11, at 6.30 p.m., at 85/88, The Minories, Tower Hill, E.1. "A Note on the Air Supply to the larger type of Motor Vessel," by Captain P. T. Brown, M.C.

THE INSTITUTION OF ELECTRICAL ENGINEERS: NORTH MIDLAND STUDENTS' SECTION.—Tuesday, March 11, at 7 p.m., at the Technical College, Bradford. "Railway Electrification," by Mr. A. J. Sayers.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—Tuesday, March 11, at 7 p.m., at the North British (Waverley) Station Hotel, Edinburgh. Paper: "The Design of Apparatus for the Protection of Alternating-Current Circuits," by A. S. FitzGerald.

THE INSTITUTION OF RAILWAY ENGINEERS (INCORPORATED).—Wednesday, March 12, at 6.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C.2. Paper: "Electric Signal Machines," by J. Boot.

THE INSTITUTION OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOCIATION.—Wednesday, March 12, at 6 p.m., at the University, Edmund Street, Birmingham Institution Lectures: "The Work of an Engineer's Office" (Lecture I), by Mr. J. Mitchell Moncrieff, C.B.E. Thursday, March 13, at 6 p.m. "The Work of an Engineer's Office" (Lecture II), by Mr. A. J. Hill, C.B.E.

THE INSTITUTION OF ENGINEERS-IN-CHARGE.—Wednesday, March 12, at 7.30 p.m., at the St. Bride Institute, Bride-lane, Fleet-street, E.C.4. Paper: "Small Turbines and their Application," by Mr. K. Anderson.

THE INSTITUTION OF CIVIL ENGINEERS: INFORMAL MEETING.—Wednesday, March 12, at 7 p.m. Subjects for discussion: "CO_2 Recorders," to be introduced by C. E. Stromeyer, O.B.E., M.Inst.C.E.; and "The Practical Testing of Steam Boilers," introduced by Robert Hodson Parsons, Assoc.M.Inst.C.E. (Discussion adjourned from January 16.)

THE RADIO SOCIETY OF GREAT BRITAIN.—Wednesday, March 12, at 6 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C.2. Informal meeting. Mr. F. Phillips will open a discussion upon "Amplifiers for Short Wave Reception."

THE INSTITUTE OF METALS.—Wednesday, March 12, and Thursday, March 13, at 10 a.m., in the Hall of the Institution of Mechanical Engineers, Storey's Gate, S.W.1. Annual General Meeting, Wednesday, March 12, at 10 a.m. Presidential address. Papers to be read and discussed: "The Brittle Ranges in Brass as shown by the Izod Impact Test," by D. Bunting, M.Sc. "Determination of the Thermal Coefficients of Expansion of Some Commercial Metals and Alloys" (Note) by J. Newton Friend, D.Sc., Ph.D., F.I.C., and R. H. Vallance, M.Sc. Wednesday afternoon, at 2.30 p.m. "The Investigation of a Fatigue Failure of Brass Tubes in a Feed-water Heater—with a Consideration of the Nature of Fatigue," by W. E. W. Millington, M.Inst.C.E., M.I.Mech.E., and Professor F. C. Thompson, D.Met., B.Sc. "The Tensile Properties of Aluminium at High Temperatures," by Thomas Martin, M.Sc., F.I.C. "The Relation between the Tensile Strength and the Electrical Resistivity of Commercially Pure Copper" (Note), by W. E. Alkins, M.Sc. "Note on the Effect of Cold-Drawing and Annealing on some Electro-Chemical Properties of a Low-Tin Bronze," by Stuart H. J. Wilson, B.Sc., M.Sc. Wednesday evening, at 7.15 p.m. for 7.30 p.m. Annual dinner at the Trocadero Restaurant, Piccadilly Circus, W.1. Thursday, March 13, at 10 a.m. "The Relative Corrosion of Zinc and Lead in Solutions of Inorganic Salts," by J. Newton Friend, D.Sc., Ph.D., F.I.C., and J. S. Tidmus, B.Sc. "X-ray Studies on the Copper-Aluminium Alloys," by E. R. Jette, G. Phragmén and A. F. Westgren, Ph.D. "The Effect of Casting Temperature on the Physical Properties of a Sand-Cast Zinc-Bronze" (Note), by Francis W. Rowe, B.Sc. "Copper-Zinc Alloys which Expand on Solidification," by K. Iokibe, M.Sc. Thursday afternoon, at 2.30 p.m. "The Constitution of the Alloys of Copper and Cadmium," by C. H. M. Jenkins, B.Sc., A.R.S.M., and D. Hanson, D.Sc. "The Aluminium-Copper Alloys: Alloys of Intermediate Composition," by David Stockdale, B.A. "The Cadmium-Lead-Zinc System," by Maurice Cook, M.Sc., Ph.D. "The Equilibrium Diagram of the Copper-Tin System," by M. Isihara.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, March 14, at 7.30 p.m., at 39, Victoria-street, S.W.1. Ordinary meeting. A paper on "Water-Tube Boilers" will be read by Mr. L. M. Jockel.

33,000-VOLT BULK SUPPLY SCHEME FOR GORSEINON.

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(*For Description, see Page* 295.)

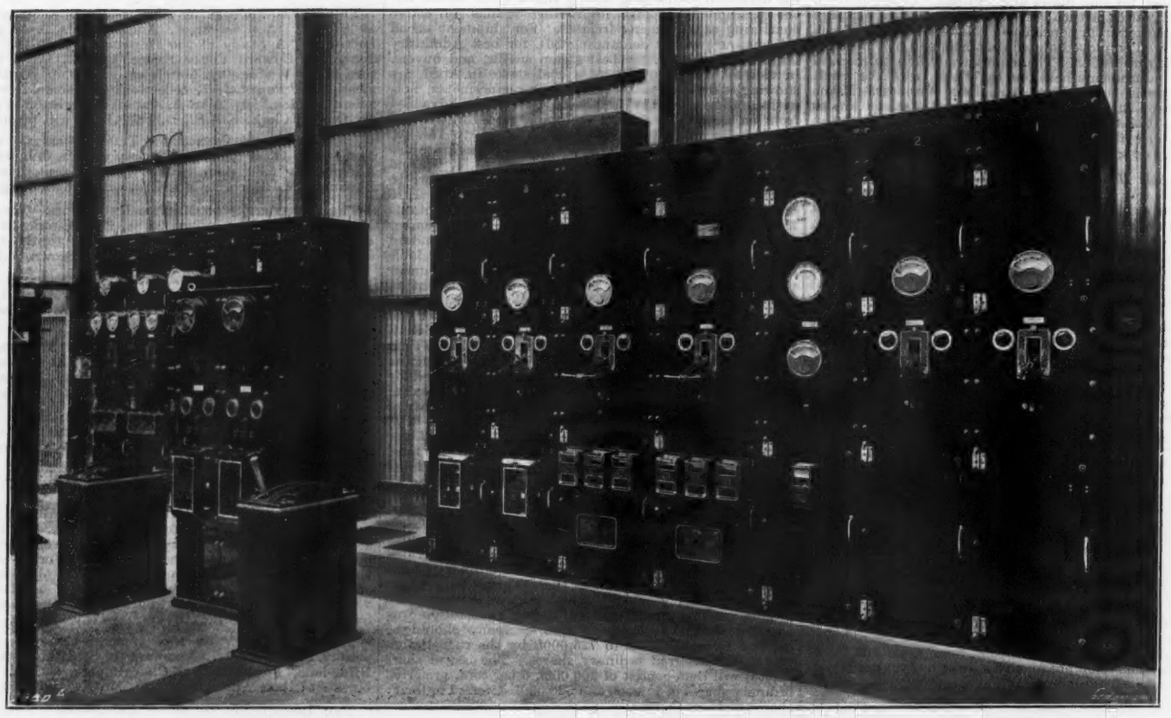

FIG. 24. INTERIOR OF PONTARDULAIS SUBSTATION.

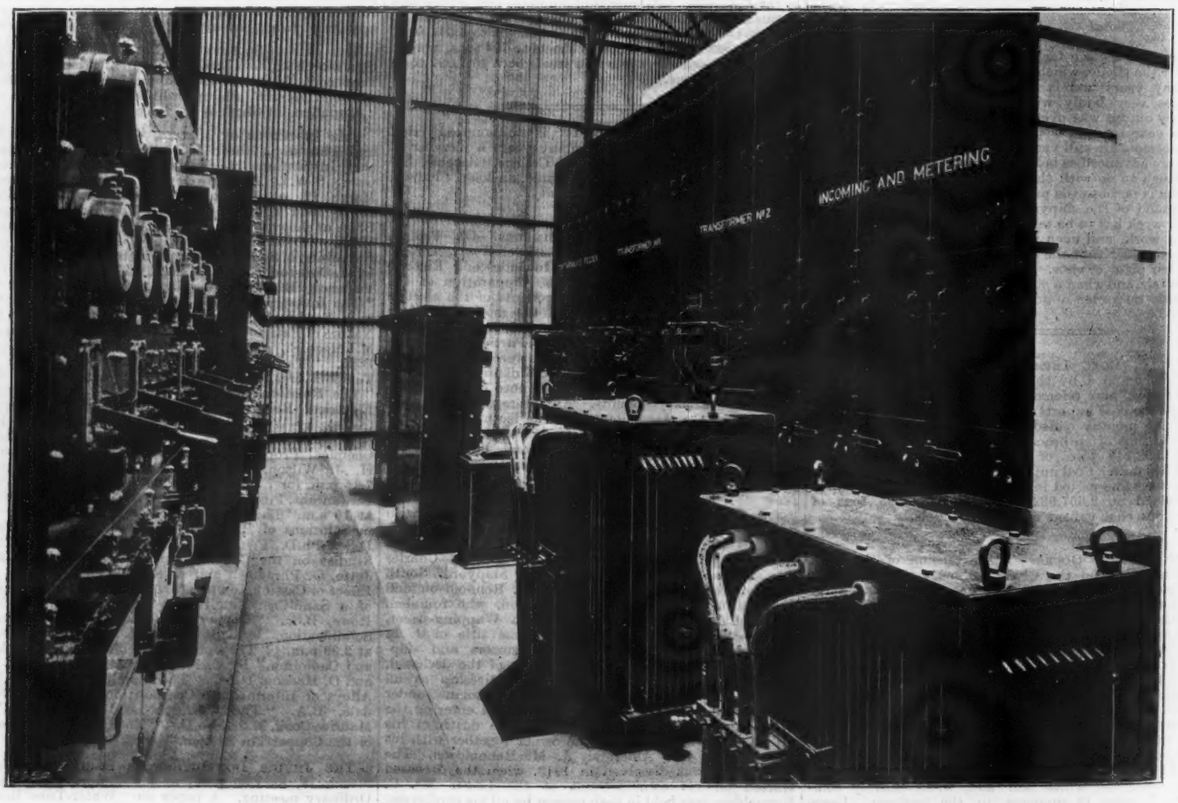

FIG. 25. INTERIOR OF GORSEINON SUBSTATION.

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

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ENGINEERING.

FRIDAY, MARCH 7, 1924.

MINE RESCUE APPARATUS.

WITH the publication of its Third Report to the Advisory Council of the Department of Scientific and Industrial Research*, the Committee appointed in 1917 to investigate the types of breathing apparatus used in coal mines, brings its labours to an end. The subject matter of its work has the peculiar difficulty that, while the effective working of breathing apparatus is literally of vital importance, little or no margin of safety has been found possible in its design and construction, and no purely mechanical means of testing its efficiency has been found satisfactory. Whether this is the last word that will be said ultimately, it seems to be the last that can be said at present; and though all parties would doubtless have been better pleased with a more objective result, the work of the Committee represents a valuable addition to such knowledge as existed when their investigation began, and has provided a sufficiently definite means of discriminating between such appliances as are or may become available. The members of the Committee were Sir (at the outset Mr.) William Walker, successively Acting Chief and Chief Inspector of Mines, but now retired, Professor H. Briggs, D.Sc., Head of the Department of Mining in the Heriot-Watt College, Edinburgh, and Dr. J. S. Haldane, already known both as a physiologist and as having conducted investigations into the effect of high altitudes and of the atmosphere of hot and deep mines on those who were exposed to them.

The report contains critical descriptions of appliances already in use and of others designed during and in the course of the investigations, but perhaps their most important result has been to establish a standard code for testing such appliances before their use is authorised, and to analyse experimentally and critically the factors of danger in the use of imperfect apparatus. Breathing appliances for mine use have two independent purposes. One type of apparatus is for use in an atmosphere that cannot support respiration, or even is directly poisonous; the other is for the revival of persons who have been attacked by such an atmosphere and become unconscious. Though it would have been more satisfactory for each of such appliances to have been tried sufficiently by mechanical and perhaps chemical tests, such could only have been set up on the strength of the physiological results of actual trial; and at present no complete test of the apparatus independent of the operator has been devised for appliances to be used for normal breathing in a foul atmosphere. The physiological observations on which the present tests for this class of appliances are founded have, however, considerable interest even apart from the special purpose with which they were made, and indicate among other results a possible means of judging the fitness of a man for hard or continued muscular work. This curious bye-product of the investigation arose through the endeavour to determine how far pure oxygen or air enriched with more oxygen than its normal percentage differed from ordinary air in its effect on respiration. Some people, for instance, were under the impression that much less oxygen was consumed when it was breathed pure than even with enriched air; and very commonly the belief was held that breathing highly enriched air resulted in burning up the tissues, accompanied by excitement and violent bursts of physical energy, and followed by depression and lassitude. Either of these beliefs, if correct, would have an obvious and important bearing on practice; but as a fact each of them was found to be wholly unwarranted.

The experiments by which the matter was cleared up consisted in effect in selecting a considerable number of subjects of very various ages, physique and apparent condition, and measuring their oxygen consumption and carbonic acid production when at rest and when performing for given periods a variety of measured or sufficiently defined pieces of muscular work. It was found that each subject took an increasing amount of oxygen (measured by the percentages of carbonic acid in the air he exhaled) as the exercise became more severe, up to a limit of work that varied very widely as between different subjects. With one man, for instance, the limit was reached before he was doing 3,000 ft. lb. per minute, while with another the limit was over 10,000 ft. lb. After the limit had been reached the percentage of carbonic acid invariably fell; and though the subject could always continue the work for a long period while its amount did not exceed the limit, difficulty of breathing set in as soon as the limit was passed and rapidly made continued work intolerable, up to the point of unconsciousness if it was not stopped. With the exception that the limit was different for each man a general similarity was found in the curves showing changes in the composition of exhaled air before and after the limit was reached, whatever the physical condition of the subject. When the measurements were taken on enriched air or oxygen a limit was similarly reached, after which the percentage of carbonic acid fell; but on comparing the position of the limits or crests of each subject with and without enrichment of air by oxygen it was found that the fitter the subject, the less he was assisted by enrichment, and the closer to each other were the limits with and without enrichment.

The report suggests that a man's stamina or power of supporting sustained physical effort may usefully be measured by the work he does when producing and exhaling his maximum of carbonic acid, while his fitness may be measured by the ratio of the maximum percentages of carbonic acid in the exhaled air when inhaling air and oxygen respectively. Thus, for work that may demand considerable endurance a man would not be regarded as suitable who on a particular type of ergometer—a stationary cycle worked with the legs against a weight—did less than 6,000 ft.-lb. per minute when exhaling his maximum of carbonic acid, and his fitness should be such that when working on air he exhales a maximum of not less than 75 per cent. of the quantity of carbonic acid that he produces as a maximum when working on pure oxygen. As a fact a thoroughly strong and fit man produces about the same amount with either gas until the maximum is past—that is to say, when engaged on work that is not excessive—

* Third Report of the Mine Rescue Apparatus Committee. H. M. Stationary Office. [1*s.* net.]

while a man in poor condition may produce with air less than half as much as with oxygen; but when the work increases beyond the maximum production of carbonic acid—*i.e.*, with excessive work—all men produce more carbonic acid with oxygen than with air.

The physiological reason for these differences is in substance that, whether with air or pure oxygen, the fit man's blood combines with oxygen up to saturation during the period of an inhalation, while the less fit man's blood only gets partially saturated, and, therefore, in the attempt to provide the oxygen required by the work the less fit man has to inhale a larger volume of air, and thus to dilute the percentage of carbonic acid in the exhaled breath. Thus when breathing enriched air or even pure oxygen the fit man gets no advantage over what he gets when breathing air, because while doing work that is not excessive, the quantity of oxygen that is required for the work is furnished by what his lungs pass into his blood from the air. The less fit man, on the other hand, is short of oxygen unless the rate at which his lungs pass it into his blood is increased by increasing the partial pressure of the oxygen, as, of course, is done by enriching the air. It was found that for this purpose no advantage was gained by increasing the oxygen percentage over 60.

The quantity of air required by a man at work even within the limit of efficient working, as described above, is ten or more times as much as what is required when at rest, and it is accordingly impossible to carry enough in a rescue apparatus unless the same air can be breathed again and again. This is made possible by passing the exhaled air through granulated caustic soda, and experiments were made by Dr. Elizabeth Gilchrist and Mr. D. Penman to ascertain precisely how this regenerating substance works, and the best conditions for assuming its uninterrupted action. It appeared that the action was impeded by either too much or too little moisture in the exhaled air, and by either too high or too low a temperature; below 10 deg. C. and above 100 deg. C. the efficiency was extremely poor. Accordingly it is desirable that the available heat should be distributed over the soda container as uniformly as possible, to prevent unduly energetic action and rise of temperature at one part or insufficient temperature and action at another. The particles should be of a size and shape that will give a fair exposure of reacting surface, the extent required varying with the extent to which favourable conditions of moisture and temperature are obtained, and in order to allow room for expansion the volume of interstitial space must be greater than that of the caustic soda granules themselves. When all these circumstances are favourable and the absorption is therefore at its best the granules may swell to as much as three times their original linear dimensions, the caustic soda being first softened by the moisture and surrounded by combination with the carbonic acid with a shell of carbonate, through which the softened soda from within penetrates by capillary action, until under the most satisfactory conditions the soda has been converted entirely into a shell of carbonate. This analysis of the process that actually goes on in the purifier has given useful data for designing and using that essential part of rescue apparatus.

The present report is concerned principally with appliances deriving their oxygen from liquefied gas—either air or oxygen—and draws attention to the great advantage they have over apparatus working with compressed oxygen in respect of their much greater simplicity, and the absence of high-pressure parts. A disadvantage of liquid air is that unless considerable freedom for evaporation is given the nitrogen, which boils at 12 deg. C. lower than the oxygen, comes off as an earlier fraction of the evaporation, and in order to assure a respirable atmosphere the liquid has to be taken up in an absorbent such as calcined asbestos wool, and after the vessel is once charged evaporates at the same rate whether the apparatus is in use or not. It is suggested that, once the cost and intricacy of the liquefying plant has been faced, advantage would be found in installing oxygen liquefiers, the product of which could be used for medical and mining purposes as well as for rescue plant, and would save the several pounds weight of liquid nitrogen that has to be carried in liquid-air appliances.

The use of liquid oxygen would, moreover, permit the application to rescue apparatus of Mr. E. A. Griffiths' vaporiser. In this apparatus not only is the liquid stored in a Dewar flask, so reducing the ordinary rate of evaporation much below what is found in a less well insulated vessel, but also a device is provided which short circuits the insulation to a greater or less extent as may be desired, and thus enables the loss through evaporation when out of use to be kept at the lowest possible, and the evaporation to be increased as desired when the apparatus is in use. This vaporiser has been used with satisfactory results in revival apparatus.

An important suggestion in regard to revival apparatus is that, having regard to the fact that the process of artificial respiration replaces the atmosphere of the lungs by whatever gas is supplied by the apparatus, and that normally the respiratory centres by which the process of respiration is controlled are stimulated by carbonic acid and not by oxygen, revival apparatus should be supplied with oxygen mixed with 5 per cent. of carbonic acid, from which it is believed that much better results would be obtained than from pure oxygen. A further important conclusion, reached after trial of the chief appliances yet produced for the mechanical application of forced breathing, is that the use of any such appliance is physiologically unsound and may be directly dangerous.

The report describes the latest types of apparatus, and the tests that have to be applied to any type—or to any fresh manufacture of an old type—which not only verify its mechanical soundness but also include a number of 2-hour trials on different men, so as to make sure that the apparatus works conveniently and is adequate in actual practice. In the recommendations on modifications of the tests that should be applied before official approval is given to liquid air rescue apparatus the Committee was divided in opinion as to the minimum feed of oxygen. Basing themselves on the apprehension that most oxygen may be wanted at the end of the period of use, when the delivery would be at a minimum, Sir W. Walker and Professor Briggs recommended a factor of safety of 50 per cent. on the normal requirement of 2 litres per minute. Dr. Haldane, on the other hand, considers that if a minimum of 2 litres per minute is assured throughout the entire period, it will be sufficient to prevent collapse of the wearer, who would have sufficient warning to desist from excessive exertion by the excessive panting that would occur if he was doing more work than the 2 litres would support.

UNEMPLOYMENT IN ITS RELATION TO ENGINEERING PRODUCTION COSTS.

UNDER the Unemployment Insurance Scheme the number of unemployed persons officially recorded continues very high, and the contributions levied from employers and provided also by the State, amount to a serious total. It is probable that the full extent of this burden is not generally realised, and also that the official figures are not a measure of the real and ultimate burden upon industry arising from unemployment.

To take first the unemployment insurance contributions: from July, 1922, to July, 1923, the employers' contributions amounted to 18,000,000*l.*, and the State contributions to 12,500,000*l.*, making together 30,500,000*l.* to be provided directly by industry or indirectly to a great extent through taxation. In addition to that, during the last four years a debt has been accumulating owing to the receipts from the Unemployment Fund not keeping pace with the expenditure on benefits, &c. This debt on June 30, 1923, amounted to 15,600,000*l.* and will have to be discharged out of future contributions. Further, in the Ministry of Labour's Report on National Unemployment Insurance just issued the following remarks are made: "The time has almost come for taking stock of the situation in all its aspects and deciding upon the line of development which may appear to offer the best chance of reaching a solution of the permanent problem of a fluctuating demand for labour." Here again is an indication of increased expenditure that was already contemplated by the late Government and is likely to be put into practice before long by the present administration. In fact, a commencement has already been made in the Unemployment Insurance Act now before the House of Commons, closing the "gap" in benefits. Although a relatively small amendment it is estimated to cost about 500,000*l.* per annum.

It will appear then that a revival of trade which begins to absorb the unemployed will only continue if it is sufficiently robust to overcome these loads which tend to throttle it even before it gets under way. Unfortunately the most serious aspect of the problem still remains to be considered. It has been claimed, and it is indisputably true, that the unemployment insurance figures do not represent the true extent of unemployment as regards the gross number of unemployed. Fuller investigation also reveals that they do not represent a true percentage. This is partly due to the fact that unemployment in certain trades not covered by unemployment insurance is of a high percentage, but still more by the fact that no allowance is made for the young persons becoming available for employment at the age of 14 who are not covered by the Act until they are 16. This factor is of all the greater importance as it greatly outweighs the annual wastage from deaths, retirement and emigration.

It may be worth while perhaps to examine the results of this investigation in detail. The position in 1921 as far as can be ascertained was as given

TABLE I.

Year.	Population.	Available Occupational Employees.*	Unemployed in Insured Trades.
	Millions.	Millions.	Millions.
1911	36	16	¼
1921	37·8	17	1¼

* The expression "Occupational Employees" is used to represent the number of persons available for work in all occupations in a subordinate capacity, *i.e.*, at a salary of 250*l.* per annum or under.

in Table I annexed. From this it will be seen that in 1921 the excess of unemployment in insured trades over that in 1911 was 1,000,000, and the excess of occupational employees in 1921 over those in 1911 was also 1,000,000, so that both in 1921 and 1911 we employed roughly the same number of persons. This million of excess unemployed in 1921 may be reckoned as a definite cost of the war, and being an abnormal increase might be expected to be removed by abnormal measures, such as the undertaking of revenue-producing works coupled with the adoption of a sound financial policy. The process of increasing our capital equipment, which would follow from the adoption of the first of these measures, would not only absorb a great portion of the unemployed, but also by reducing costs of transportation tend to stimulate a revival of demand. Assuming that trade were to revive generally we should then be left with that portion of the unemployed which is "unemployable," which cannot be less than 250,000 and may exceed 500,000.

But all this would only absorb the war increase of unemployment which was already present in 1921. From that date and every year in future, as far as can be seen at present, we have to face a large annual net increase of persons available for employment. This increase represents the excess of the numbers in any year becoming 14 and 15 years of age over the numbers leaving occupations from death, retirement and emigration after making allowance for that proportion of the total population who do not normally enter industry. In 1921, 1922 and 1923 the excess on this basis was at least 250,000 per annum. In other words, we shall have to provide employment every year for 250,000 more persons than in the preceding year, which means providing capital equipment for them to use. It has been estimated that "not less than 1,000*l.* in new capital outlay will equip a working man with organisation and appliances sufficient to render his labour efficient, and to house and supply himself and his family."* If this estimate is correct we shall need savings at the

* J. M. Keynes in "A Tract on Monetary Reform."

rate of 250,000,000*l.* a year to keep pace with the annual net increase in the labour supply. Any attempt to tackle unemployment scientifically must clearly take this factor into consideration as well as the imposing figure of the present abnormal volume of unemployment.

A useful check on the unemployment insurance figures, taken in conjunction with the calculation above, is provided by an examination of the Workmen's Compensation Act. The number of persons covered by this Act provides an index of persons in seven of the principal industries who are definitely employed on full-time employment throughout the year. The figures for these seven principal industries are given in Table II annexed.

TABLE II.—*Figures Applicable to Seven Principal Industries.*

Year.	In Full-time Employment.	Difference from the Preceding Year	Per cent. Difference from Preceding Year
1920	8,348,150	—	—
1921	7,315,866	−1,032,284	−12·37 per cent.
1922	7,205,609	−110,255	−1·5 per cent.

The number of available occupational employees in the whole country in the year 1920 was roughly 17,000,000, and unemployment in that year was at its normal figure—an average for the year of 3·5 per cent., which represents "unemployables." From this it may be assumed that out of the total occupational employees in the year 1920 approximately 16,388,000 persons were employed. Applying the employment decrease percentage derived from workmen's compensation statistics as shown in Table II to this figure, we get 14,358,000 for 1921 and 14,141,000 for 1922 as the numbers employed throughout the whole country. The total number of available occupational employees for the years 1921 and 1922 equals 17,000,000 plus the annual net increase for each of these two years, and by subtracting the number of employed under this percentage from the total number of occupational employees we may claim to get an approximate idea of the true extent of unemployment. This would give us a total unemployment figure of 2,892,000 and 3,359,000 for 1921 and 1922 respectively.

The importance of the divergence between true unemployment and the unemployment insurance figure to the engineering industry is considerable. In the event of a revival of trade the first step will be the absorption of the reserve labour which is represented by short-time workers who are not fully shown in the unemployment insurance figures, and the speeding up of those employed and not working at full efficiency. The second will be the absorption of juveniles. The third will be the employment of the unemployed persons shown in insured trades unemployment figures except the "unemployables." But after all this there will be the absorption of unemployed persons not previously employed at all or turning over from their present industry. This "turn-over" of labour towards prosperous industries is a factor of great importance and is recognised as such in the United States; but as much attention has not been paid to it in this country as might be expected considering the experience we had during the Great War.

The increase in the male population available for occupational employment between the ages of 15 and 65, and between the years 1911 to 1921 was 780,000? The increase in the number of employees in engineering, shipbuilding, metals, vehicles and the iron and steel trades was 575,000, or roughly 75 per cent. of the total increase during the same period. This may appear incredible at first sight. It is partly to be explained by the turnover or redistribution of employees who gravitated from other industries less affected by the stimulus of the war to the engineering industry.

It is instructive to re-state these conclusions in terms of trade-volume. In order to absorb the "deadweight" unemployment arising from the war we required in 1921 an increase of 15 per cent. in our volume of trade as compared with 1911. Each year since 1921 we have required an increase of approximately 4 per cent. on the 1911 trade-volume to keep pace with the annual net increase. This by now amounts to 8 per cent. Thus, at the present moment we need an increase of approximately 23 per cent. over pre-war volume to wipe out the existing load of unemployment, and an annual increase of 4 per cent. or 5 per cent. in future on the 1911 volume until a new normal balance is created between those who are available for occupational employment and those who for the reasons referred to above leave such employment. Actually the volume of our trade to-day is less than it was in 1911.

The problem stated above is a serious one, but at the same time it must not be forgotten that if revival comes the industry will be faced as it is now faced with demands for increased wages. Ever since the principle of unemployment insurance was instituted in 1911 employers have, in truth, been in a cleft stick. Before the war it was not felt owing to the equable state of unemployment, but now they have to choose the lesser evil between unemployment and heavy contributions, or employment and higher wages. From a national point of view, as well as from their own, the latter appears the lesser of the two evils, subject always to the fundamental consideration that everything depends on the revival of trade, which means the finding of purchasers and implies attractive selling prices. These can only be secured by reduction in costs, and to this we directed attention in a leading article on page 273 of our issue of February 29.

APPLIED RESEARCH IN ELECTRICAL ENGINEERING.

ELECTRICAL design, more directly than any other form of engineering design, rests on theoretical considerations, and the electrical industry, as a consequence, forms one of the most promising fields for applied research—research, that is, directed to the accumulation of useful data and the investigation of points which are the occasion of trouble in practice. A great part of any class of applied research is necessarily concerned with investigations into the properties of materials, and as the number of such properties utilised by electrical engineers is considerably greater than those utilised in most other branches of engineering, a larger field of work than usual is made available. General engineering is not as a rule concerned with anything more than the mechanical and thermal properties of the materials which it uses, with perhaps the chemical properties added in some cases. To these, however, electrical engineering adds electrical conductivity, dielectric strength, magnetic properties in the case of iron compounds, and very many special matters such as the effect of arcing on transformer and switch oils, and of radio frequencies on resistivity and other electrical properties.

With the large field available and the immediate applicability of so many of the results obtained, it is not surprising to find the British Electrical and Allied Industries Research Association engaged in a very large range of work, and that the results obtained are of practical value is made sufficiently evident by the fact that the membership of the Association includes almost all the electrical manufacturing firms in the country and a great many of those which, although not directly electrical manufacturers, are closely concerned owing to their connection with power house equipment. The immediate practical value that applied research of the type the Association is engaged on may at times have is illustrated by the statement in the third annual report, which has just been issued, to the effect that the total savings to the electrical industry made possible by the research on the heating of buried cables amounts annually to a larger sum than the total expenditure of the Association and its predecessor, the Electrical Research Committee, from the commencement of the latter to the present day.

Electrical research of the practical character to which the Association restricts itself is of as much interest to the financial and supply sides of the electrical industry as to the manufacturer, and one of the most interesting matters dealt with in the report is the formation of a class of Associate Member in the course of last year. The associate membership list is as yet not very long, but includes the Corporations of Birmingham, Glasgow, Manchester and Sheffield, the Yorkshire Electric Power Company and the Kensington and Knightsbridge and Westminster Electric supply companies, and with these examples one may expect to see the list grow to a considerable extent in the future. That the Association deserves and is entitled to the support of bodies of this class is made evident by an examination of the work it has done and is doing, and without going into a long list of activities it will be sufficient to instance the investigation into problems of condenser corrosion, which is obviously quite as much a users' matter as one for manufacturers. The nature of the organisation of the association is such that in determining whether or not a particular piece of work shall be undertaken the primary consideration must be the benefit of the industry as a whole, but confidential work can be, and has been, carried out for groups of manufacturers when adequate support has been forthcoming from those interested.

Apart from the advantages which the Association offers in being able to carry out researches which few or no individual manufacturers could undertake, the authoritative position which it has established enables it to obtain facilities and advantages to do work of such a character which would not otherwise be available, an instance being afforded by the assistance which has been rendered by the Newcastle-upon-Tyne Electric Supply Company in connection with the important researches into switching and arcing phenomena. The Association may be strongly recommended to any electrical manufacturing or supply company which is not as yet connected with it.

INVENTION AND THE EMPLOYEE.

THE legal definition of an invention implies that it must be essentially an article of manufacture. Thus ideas or schemes do not come within this definition and are therefore excluded from the scope of the term. An equally important matter is that an invention must be new, useful and show something more than skilled construction. Novelty and utility may be readily recognised in an invention, but great discrimination may be necessary before it can be established that the subject matter is no mere application of skill and knowledge, such as might be possessed by anyone who is fully acquainted with the details of the art or industry concerned. These matters and the issues involved in relation to them, were discussed by Mr. E. C. R. Marks in a paper on "Engineers, Inventions and Patents," which he read to the North Western Branch of the Institution of Mechanical Engineers on Thursday, February 28.

In the production of something entirely new a number of very vexed questions are frequently involved. For instance, there are the problems connected with the rights of ownership when a patentable device is produced in the course of an employee's usual activity in a works. There must be many misunderstandings in regard to the position, for disgruntled individuals are frequently met, who assert that their employers having "stolen" their inventions, have dismissed them from their service. It is a common attribute of such men that they show themselves incapable of further pioneer work and it can only be taken that they were employed to set down on paper what was suggested to them by men of larger capacity and greater resource. Mr. Marks, in referring to this side of the subject, stated that although the name of the actual inventor must appear in the specification and the application must bear his signature, these facts did not imply ownership. A fully qualified and capable draughtsman, for instance, might be engaged by his employers to design and prepare drawings of some machine or appliance for a specific purpose and of such a character that may be required by, and sold to, a great number of users. In this case the ownership of any patent which was taken out remained the property of the employers. Should, however, a worker in another field of activity, say

a clerk, produce an invention of value it would be the employee's property for he was not engaged to do design work as an item of service in his employment. Anything such an individual achieves in the invention of devices remained entirely his own personal property. The position broadly was therefore clear, as far as its legal significance was concerned, and it was only that phase which the lecturer considered.

There is, however, another standpoint from which the question of such inventions must be viewed. Encouragement should be given by every means available, that all the resources of the personnel of an organisation be utilised in keeping the concern, with which they are associated, right in the front line of development. Legally the position of an inventive employee may be quite clear, but a rigid adherence to the letter of the law may act detrimentally to the interests of the firm. An exceptional employee deserves, and frequently gets, promotion and other forms of encouragement and his association in the ownership of patents with his employers, given to him quite apart from any question of legal right, may do much to help the fostering of schemes for improvements, to perfect many of the processes used in the works and to introduce new ones. By reasonably generous treatment and financial recognition by a gift of participation in the yield from an invention, many of the difficulties involved in the legal questions of ownership of patents may be mollified. In this simple way of giving recognition to ability the wholehearted devotion of an exceptional employee to the organisation he is a part of may be completely won. Loyalty among workers of any type is the greatest asset that a commercial or any other organisation can have, and once the inventive employees find they are being treated generously and that they have a share in the well-being of the firm, they would be poor types of humanity if they did not give of their best. A similar question has sometimes arisen in connection with the research work conducted for associations or individual manufacturers. The legal position is perhaps even more simple than in the other case but, here again, a broadminded outlook and tactful administration in dealing with questions of recompense may be of much greater moment than any rigid adherence to the legal outlook. After all, the legal position must be recognised by the employees, but tact in dealing with any situation that arises may lead to improved relationships between the parties and be a benefit to all.

REST PAUSES IN LIGHT REPETITION WORK.

IN various proverbs we have long been told to hasten slowly and that more haste may mean less speed, but as yet there is little guidance as to the proportions in which rest may best be mixed with speed in industrial work. The Industrial Fatigue Research Board is now trying to devote its resources as much as possible to problems having a general interest to all or a variety of industries, and among its inquiries into other questions is collecting information on the effect of the systematic introduction of rest pauses. An instalment of its results has now been published,* dealing with observations by Dr. H. M. Vernon and Mr. T. Bedford, assisted by Mr. C. G. Warner, on the influence of rest pauses on light industrial repetition work, and some laboratory experiments on rest pauses by Mr. S. Wyall, assisted by Mr. A. D. Ogden.

In the industrial part of the work the material studied appears to have been unusually free from variations in working conditions other than the introduction of the pauses. An unavoidable variation was that after the introduction of the systematic pauses the workers, who were paid on piece work, did more or less reduce the irregular rests or changes of occupation that they had previously been in the habit of taking. The purpose of the observations was, however, not so much to obtain exact numerical data as to ascertain the general effect of the introduction of the pauses; and for this purpose the automatic abandonment of some of the irregular intervals of rest seems not to have been sufficient in its effect to mask the results of the systematic rests. These results varied with individuals and with different operations; but in round figures they showed that with the intercalation of a 10 or 15 minutes' interval into a 4 or 4½-hour spell of work an increase in daily output of the order of 5 to 10 per cent. might be obtained. In one instance a still more ample system of rest pauses was adopted, girls assembling bicycle-chain constituents on pendulum presses being given rests of five minutes four times during the morning and three times during the afternoon. Their work was observed for some 14 months, during the first six weeks of which the rest pauses were not introduced. Assuming that their output during these six weeks represented fairly their normal output on continuous work—though by itself the period seems full short to justify this assumption—the result of the introduction of the rest pauses was that the daily output increased immediately and steadily, reaching in 24 weeks a fairly uniform level some 13 per cent. higher than in the pre-pause six weeks, which it maintained throughout the remaining 32 weeks, in spite of the sacrifice in rests of 7 per cent. of the working time. The example is striking, because each operation only took about 9 seconds, and, as it required close attention, must have involved a considerable amount of concentrated work and rapid repetition. A notable circumstance in groups of observations that were examined on the point was that the slowest workers derived considerably more advantage from the rest pauses than the quicker. Thus in each of two different operations the hourly improvement of the output of the slowest group of workers, when the whole of the workers had been divided into three groups according to their speed of working, showed more than double the improvement from rest pauses that was shown by the fastest, and the intermediate girls showed an intermediate extent of improvement.

The laboratory experiments consisted of two main groups, each carried out in two 2½-hour spells per day for an unstated number of days on an unstated number of persons; the reason for reticence on these points is not obvious. In one group the unhappy subject—or subjects—was set to do simple addition sums, continuously on one or more days, on one or more other days with a 15 minutes' break in the middle of each spell, and on one or more other days with two 7½-minute breaks. Apparently each test did actually run for more than three days, but the text is not conclusive on the point. Here, therefore, the comparison was made between wholly continuous work, without either irregular breaks or changes of occupation, and work relieved by the rest pauses. Whether output was reckoned by the number of sums worked or the number worked correctly is not stated, but no doubt it was in some constant unit, so that the results are comparable. They showed an improvement of about 22 per cent. with the 15-minute rest and about half as much with the two 7½-minute rests; in each case a marked tendency to improve was shown as the epoch of the rest approached. In one instance it is said that the subject had been employed on similar work for some weeks before the test and his daily output had become fairly constant. The improvement was evidently due to increased speed of working following on the mid-spell relief and also, as a rule, anticipating it.

The suggestion is made that where a more or less uniform work curve for the day can be plotted and shows, as normally it will show, decreased output at more or less definite epochs, the rest pause or pauses should be taken just before this decrease, and may then be expected to postpone or avoid it. In effect the problem is to put in pauses at such points and of such lengths as will recuperate the energy lost through work, if the existing intervals of rest are not sufficient for the purpose. The second group of experiments illustrates in another way the recuperative effect of intervals. The test was to pull as hard as possible on a spring balance; in one series of the group the pull was made every half-minute, and in another every quarter-minute. The output was presumably reckoned as the aggregate weight pulled. It was found that with the half-minute pulls the subject settled down after the first hour to an approximately uniform output, which was maintained for the rest of the morning and the whole of the afternoon. With the quarter-minute pulls the output tended to decrease after the first hour, and though somewhat greater during the morning than the half-minute output, fell and remained below it after the first half-hour of the afternoon.

Where definite rest-spells are introduced it is suggested that equivalent results might be obtained by substituting change of occupation, such as collecting or delivering material, for actual rest, as was done by G. H. Miles and O. Skilbeck in a factory, with a gain of 14 per cent. in output. Considerable difference in the effect of rest pauses is said to have been found according to the way in which they were spent; four additioners, for instance, found a gain of about 9 per cent. after absolute rest or seated conversation, as against only about 3 per cent. after drinking tea and 1½ per cent. after walking. The evidence, as the report admits, is "merely suggestive"; but to such extent as it goes, it seems to show that the manner in which the rest is spent may have some effect on its value. In industry, however, with spells of four hours or upwards there seems some probability that a little food with or without tea works well. One firm found it even of advantage to issue thermos flasks to each worker at wholesale cost price, so that workers could all take tea simultaneously and use fully the whole of the rest pause.

The net effect of the report is to add a little more evidence to the existing accumulation of results indicating that rest pauses may increase daily output, and to make suggestions as to when and to what extent they should be applied. It does not pretend to be conclusive as to more than that employers would be well advised to make experiments on their own works, so as to determine what is best for the operations and workers in question. The attention of such employers is called to the fact that results may take some months to reach their full extent, that the way in which the pause is spent may be material, and that beginners may be found to derive special benefit from the suggested relief.

* Two Studies on Rest Pauses in Industry. H.M. Stationery Office, 1s. 6d. net.

THE CRYSTALLINE STRUCTURE OF ORGANIC SUBSTANCES.

ON Thursday, February 28, Sir W. H. Bragg, F.R.S., delivered at the Royal Institution the concluding lecture of his course on the above subject.

He said that in several of the models he had exhibited there were molecules which were mirror reflections of each other, and that crystals were often found similarly related, as, for example, the right- and left-handed quartz crystals represented in Fig. 21. It would be seen that the faces *m*, *s*, *r* in the one case formed a sort of spiral running one way in the left-handed crystal, and the other way in the right-handed crystal. This difference was associated with some very remarkable optical properties. When a beam of polarised light was passed through such a crystal the plane of polarisation was "screwed round," the rotation being greater the smaller the wave length. This phenomenon was demonstrated in the lecture, with what Professor Bragg said, were a magnificent pair of nicol prisms, which had been presented to the Royal Institution by Mrs. Tyndall. The X-ray study of crystals having this property, the speaker said, confirmed the view originally put forward by Herschell and subsequently by Pasteur that there was something in the crystal structure analogous to a "spiral staircase," and a model of the quartz crystal was exhibited which showed this structure very clearly, successive silicon atoms forming a helix, with three steps to the turn. The twist given to the plane of polarisation was however, Sir William said, of very much steeper pitch, and in the case of a sugar solution was many centimetres long. The same kind of structure was found in tartaric acid, which was famous for having given Pasteur his start in life. Pasteur found that there were two kinds of tartaric acid, one of which rotated the plane of polarisation to the left and the other to the right. Moreover, he also found that racemic acid, which was identical in chemical composition was optically inactive,

but that by bacteriological action an optically active form could be separated from this, which turned out to be 50–50 mixture of the two kinds of crystal. In addition there was a fourth form which was absolutely inactive for molecular reasons. Mr. Astbury had, Sir William continued, examined tartaric acid by means of X-rays, and found the "screw" structure predicted by Pasteur, but it was not continuous as was the helix in the case of quartz. In fact, in building up the crystal of tartaric acid a reverse screw came in when the unit patterns were put together, so that the action on light was a differential one, and hence we might have the plane of polarisation turned one way in solid tartaric acid, and in the opposite direction in a solution of this body where the molecules were free. There were, Professor Bragg added, also crystals in which right- and left-handed "screws" were found, but which had no optical activity.

Professor Bragg next proceeded to comment further on the long open chain organic molecules which he had discussed in the preceding lecture. These, he said, all appeared to stand straight up and to have the same width. The length of successive links in the chain was either 1 or 1·22 Angström units, according as the arrangement was that represented in Fig. 19 or that shown in Fig. 20 on page 275 *ante*. The former was characteristic of chains having an even number of carbon atoms, whilst the longer links corresponded to an odd number. Some measurements made were plotted in Fig. 22. The difference of the line corresponding to the phenols and that corresponding to the palmitates was due to the difference in the arrangement of the carbon atoms, as shown in Figs. 19 and 20 *ante*, already referred to.

In some of the cases examined two different chains were coupled together, but the experiments seemed to show that even when the carbon atoms at the junction were united by three bonds the length was the same as if the union had been effected by a single bond. This seemed to indicate that the change in the bonding produced no material inflection at the point of junction, and that the two consecutive chains lay pretty much in a line.

Sir William next proceeded to say that in these investigations we had become acquainted with chemical bonds of three different types. In the first place we had cases in which atoms shared electrons with one another. Each atom was now known to be constituted of a central core positively charged, round which were grouped negative electrons. In the case of hydrogen there was one positive charge at the nucleus, and this was capable of attracting one electron. Similarly, helium had two positive charges at the centre, and attracted two electrons, and so on up the list of the elements. For some unknown reason helium, when it had got its two electrons, was extraordinarily satisfied, and did not want either to get more or share what it had with other atoms, being in fact a perfectly unsociable body. Argon also belonged to the unsociable group, and hence, although it was so plentiful that there was about 18 lb. of it in the air of the lecture theatre, it passed unnoticed until finally brought to light by Lord Rayleigh and Sir William Ramsay. Argon had in fact got such a cloak of electrons that it did not want to borrow, give, or lend to any other atom.

The nucleus of the carbon atom had a positive charge of six, and round it were six electrons, of which two were in an inner, and the other four in an outer, shell, and as we proceeded up the table of the elements the number of electrons in the outer shell increased until we got to neon which had eight. For some reason unknown, however, all the atoms would like to have eight in this outer ring. Fluorine, which preceded neon in the list, had seven electrons in this outer ring, and was so greedy of gaining another that it would rob another atom of any electron not very tightly held. This element was accordingly characterised by great chemical activity, as was chlorine, which also had seven electrons in its outer shell. It was this characteristic that made these two gases so poisonous. After neon we came to sodium which, having completed a shell of eight electrons, had started a new shell with one, and this one was not very tightly held; hence, when a sodium atom met one of chlorine, this electron was pulled off, leaving the sodium atom positively charged, whilst the chlorine atom became by the robbery negatively charged; hence the two atoms now attracted each other electrostatically, and we got the compound NaCl. This was one kind of combination formed, the characteristic of which was that the two constituents were oppositely electrified. Every positively electrified body surrounded itself with as many negatively electrified bodies as it could, and it was this that caused the growth of the salt crystal, where each negatively charged chlorine atom was surrounded by six of the positively charged sodium atoms and *vice versa*. The second kind of combination might be represented by the molecule of chlorine. Here each chlorine atom had one electron less than the eight desired, and the two accordingly agreed to share one, which in this way would resemble a party

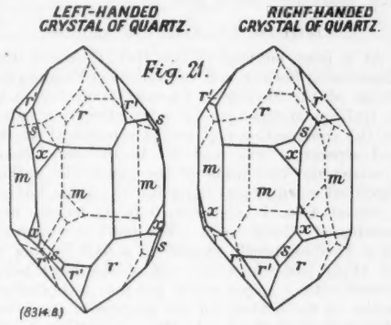


Fig. 21.

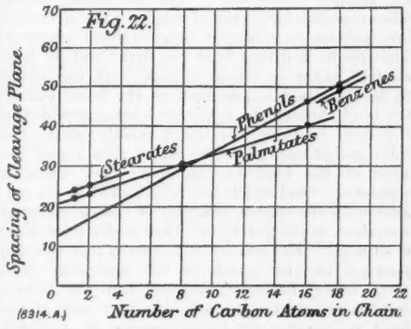


Fig. 22.

wall common to two houses. The best instance of this kind of combination was afforded by carbon, where each atom had only four electrons in the outer shell but made up the eight desired by sharing with four other carbon atoms. This was the structure of the diamond, and the bonding thus produced was exceedingly strong.

The third type of combination was due entirely to stray electric field, and it was this stray field which was responsible for organic molecules attracting each other and building up highly-complicated compounds. These stray fields were, however, weak, and such bodies accordingly melted or sublimed at low temperatures.

So long as the carbon atom shared its electrons with another atom the bonds were oriented, but if as happened with Iceland spar, as mentioned in the last lecture, the carbon was forced to give up its four electrons all sense of direction appeared to be lost and replaced by a general attraction due to its positive charge.

In conclusion Professor Bragg said that since his last lecture further experiments had been made with the good crystals of graphite at last secured, and these showed conclusively that the carbon rings in the sheets of graphite were not flat, but puckered as he had ventured to anticipate.

SWISS INDUSTRIES FAIR, BASLE.—A Swiss industries fair is to be held in Basle from May 17 to 27, to which British traders and importers are invited, since it will afford them a unique opportunity for becoming better acquainted with genuine Swiss goods of every description. Further information can be obtained from the commercial division of the Swiss Legation, London, from the Swiss Consulates in London, Manchester, Liverpool, Hull and Glasgow, and from Messrs. Thos. Cook and Son.

NOTES.

INDUSTRIAL ADMINISTRATION.

IT is apparent from the records of past students of engineering in the universities and large technical colleges that about one-half of them eventually become engaged upon administrative work. In view of this it is somewhat strange that more has not been done in acquainting the students with the fundamental principles underlying such subjects as economics, works organisation and management, and business practice. The subject was referred to by Sir Holberry Mensforth in a lecture to the graduates of the north-western branch of the Institution of Mechanical Engineers on "Works Management as a Career," when he suggested the inclusion of courses on the subjects in the colleges and examinations in them as a requirement for admission to associate membership of the Institution. Mr. Dempster Smith of the Manchester College of Technology carried the proposals a stage further when he read a paper on "Industrial Management" at a meeting of the Association of Technical Institutions on March 1. In this, after showing the necessity for the proposals, the lecturer submitted an actual scheme for a post-graduate course of one year's duration. The necessity for clear vision on questions of production is greater to-day than at any time in our industrial history, and any proposal which has that aim for its purpose must be given every consideration. Whether it is advisable to make the subject one for post-graduate work or as a constituent element in the regular course of study must be a matter of opinion, but that there is need for the treatment of these matters at some stage in an engineering student's work will be readily agreed.

THE PROPOSED ROBERT BLAIR FELLOWSHIPS.

During the period of the European war much useful work was done in the manufacture of munitions in the workshops of the technical colleges and polytechnic institutions of the country. As a result of this action funds were accumulated which are now available for the establishment of such educational facilities as are not otherwise provided for. In the case of the institutions under the London County Council a fund of 32,000*l.* was raised in this way, and the Council decided last year that this money should be used in connection with the equipment of workshops, improvements in libraries and in grants for research in engineering. So far two sums of 6,000*l.* have been set aside for the first and second purposes, and it is now proposed by the Education Committee that the Council should agree to devote the remaining 20,000*l.* to the foundation of research fellowships. It is also proposed that the fellowships should be associated with the name of Sir Robert Blair, who has rendered such signal service in the improvement of technical educational facilities in London during the last 20 years. Two "Robert Blair Fellowships for Applied Science and Technology" of the value of 450*l.* are proposed to be awarded each year to British subjects by the Education Committee and the Consultative Committee on Engineering. A preference will be given to those who have completed a course of study in London or who have been identified with the London education service, while the fellowships may also be given to young men engaged in engineering works. During the tenure of one year the fellow will undertake advanced study in applied science and technology in the British Dominions, the United States of America, or other countries abroad. A preference is to be given to those who are qualified to undertake work in engineering science. This scheme of using the munition funds to assist students of the London engineering colleges at the end of their normal courses is a very happy inspiration, and provides an excellent method of associating the name of Sir Robert Blair with the continuance of the work he has so greatly extended.

THE DESIGN OF CARGO VESSELS.

Usually cargo vessels are designed on general lines, but the ships are put on all sorts of different classes of transport work. With the scantlings steel ships usually have, great liberties in loading may be taken when the vessels are of small size, but in the

cases of large vessels great care must be taken in regard to distribution. The efficiency of a vessel must be gauged in terms of the duty it has to perform. One which has enough strength to carry ore across the Atlantic in winter might be a most unsuitable vessel, from the standpoint of efficiency, to carry timber in the Baltic in summer. This being the case, it is somewhat remarkable that the present system of designing such vessels has persisted. In carrying such a material as ore the hull is subjected, not merely to stresses due to pitching and rolling, but to the indirect effect of the great force with which the sea attacks a very stiff ship. Actual experience shows quite unmistakably that ships laden with ore are more liable to straining than those in ordinary trade. For this reason, it seems advisable to establish the rule that only ships with additional strengthening should be used in the service and that they should be given a special classification. These points were brought out in a paper on "Efficiency in Ship Construction from the Strength Point of View," which Dr. J. Bruhn read before the Institution of Engineers and Shipbuilders in Scotland on Tuesday last. As an alternative to the strengthening of scantlings of an ore carrier, he suggested increased freeboard, but the definition of what constitutes ore makes the exact specification of requirements difficult. The Norwegian Board of Trade has used this system in dealing with certain large shelter deck ships. The practice of allowing such ships to be loaded from 2 ft. to 3 ft. deeper when the tonnage opening was closed, had been found undesirable, particularly when ships were used for ore carrying. Deeper loading was therefore only permitted when more suitable cargoes were carried. On these ships there are four lines below the ordinary load-line circle, and the freeboard certificate specified which was to be considered for the five classifications of cargo. Risks due to the cargo and weather must be considered in dealing with the design of scantlings, and the only practical way that it could be done to a greater extent than now, was by having more specific classes, according to the trade in which the ships were engaged. The question of discriminating between the various trades ships were employed in, could be solved by the co-operation of the shipowners, shipbuilders, and classification societies.

SHIPS' NAVIGATION LIGHTS AND SOUND SIGNALS.

The new instructions as to the survey of ships' navigation lights and sound signals, issued by the Board of Trade this week, are based, as far as the lights are concerned, on the recommendations of the Departmental Committee on Ships' Lights, whose report was issued in July, 1922, and was referred to on page 116 of our 114th volume. The present instructions will apply to all new lights supplied to ships on and after September 1 next, but, until September 1, 1927, lights in existing ships which have been passed as complying with the 1912 instructions may continue to be passed as long as they remain in good condition and the surveyor has no special reason to doubt their efficiency. After that date, lights not complying with the new instructions will only be passed if they comply in all respects with the requirements of the Collision Regulations. In general, inspectors are required to see that a ship is provided with the lights and fog signals prescribed for the class to which she belongs, that the lights will show to the distance and in the manner laid down by the regulations, and that the fog signals carried will make the prescribed sounds. The instructions cover the use of oil lights and electric lights, both with respect to power and screening, and in the case of electric lights we notice that the lamps must be of the metal-filament type consuming either 60 watts or 100 watts, preferably the latter. Double-filament lamps are not permitted and gas-filled lamps are also regarded as unsuitable for use in ships' navigation lanterns. The procedure to be adopted by inspectors in passing coloured-glass slides for lanterns is defined in detail in the instructions, and information is also included for the guidance of manufacturers of lenses and lanterns desirous of obtaining the Board's approval of their products. The provision of Morse signalling lamps on British ships is not, at present, compulsory, although it is considered desirable that every ship should be provided with a portable oil signalling lamp; portable lamps supplied by dry batteries are not regarded as sufficiently reliable. Fixed signalling lamps, operated from the ship's electric supply system have been found generally satisfactory, and no difficulty appears to arise in attaining a reasonable standard of efficiency and range of visibility with them. As, however, a signalling lamp may be required when the ship's machinery has broken down, the above-mentioned recommendation with regard to portable oil lamps has been made. The instructions cover the dimensions of bells and of steam and other whistles or sirens, and some points in connection with the location of whistles and sirens, which must be audible for at least 2 miles in a still atmosphere, are also dealt with. Copies of the instructions are obtainable from H.M. Stationery Office, price 1*s.* net.

CENTRIFUGAL SEPARATION OF LIQUIDS.

At a joint meeting of the Hull Chemical and Engineering Society and the Chemical-Engineering Group of the Society of Chemical Industry, held in Hull on Monday last, a very interesting paper on the construction and use of centrifugal dryers and separators was read by Mr. E. A. Alliott. Towards the conclusion of the paper, the author described a centrifugal separator for liquids, having a basket 4 in. in diameter, 3 ft. in length, and running at 17,000 r.p.m. The bowl is supported on a flexible spindle carried by a ball bearing at its upper end, the lower end of the bowl being formed with a spigot which fits into a controlling device at the bottom for the purpose of steadying the motion of the bowl. The controlling device offers considerable frictional resistance to movement, but includes no rubber or other resilient material. The spindle is driven from the upper end by belt, electric motor or steam turbine, and the liquid to be separated is admitted to the lower end of the bowl through the spigot, fins being provided in the bowl to bring the liquid rapidly up to the full speed of rotation. The liquid rises round the sides of the bowl to the upper end, where a separating head which can be adjusted in accordance with the specific gravities of the constituents contained in the particular liquid under treatment, is situated. The heavier constituents flow through passages on the outside of the separating head to a lower discharge opening, and the lighter constituents travel through the inner part of the head to another discharge opening at a higher level. Several modifications of the design are possible for the treatment of liquids containing either heavy solid particles or particles of lower specific gravity than that of the liquid. The last-mentioned conditions are encountered in the clarification of some forms of glue, but an application of the machine referred to in the paper, and of particular interest to engineers, is in connection with the reduction of the ash contents of fuel oils for use in Diesel engines. In employing in Diesel engines the fuel oil normally used for boiler firing, trouble is sometimes experienced from the high ash content of the oil, which amounted, in a particular case, to 0·065 per cent. By passing this oil through the centrifugal separator, the ash content was reduced to 0·022 per cent., the latter figure being about equal to that for ordinary Diesel-engine oil; the treatment, moreover, has the additional advantage of removing any water present in the oil. Another useful application of centrifugal separation is for the treatment of water-gas tar, in which oil forms a very intractable emulsion with water. To separate the emulsion by the action of gravity and heat occupies some months, but the separation can be rapidly effected in a high-speed centrifugal owing to the fact that the finely-divided carbon present, which acts as the emulsifying agent, is removed almost immediately the emulsion enters the machine. The oil and water are then free to separate, and the separation can be effected at the rate of 170 to 180 gallons an hour. In the machine above referred to as having a bowl 4 in. in diameter, the centrifugal force exerted on the liquid amounts to about 16,950 times the force of gravity, but in a 2-in. diameter machine of the same type, which runs at 40,000 r.p.m., and is intended for laboratory work, the centrifugal force is 45,000 times that of gravity. The laboratory machine is used in connection with the preparation of serums, for separating bacteria from suspensions, and for other work of this character.

AERIAL TRANSPORT.

It is becoming increasingly difficult to advance any new arguments in favour of the development of aerial transport, and it is therefore by no means surprising that many of the points raised in a paper on this subject, presented to the Institute of Transport on Monday last by Mr. G. Holt Thomas, have been put forward on previous occasions. These arguments, however, do not seem to be as fully appreciated by the business community in this country as they are elsewhere, and that is probably sufficient reason for bringing them before the members of the Institute of Transport. We fully concur with Mr. Thomas's view that the most useful application for the aeroplane is for the long-distance transport of mails and other comparatively light goods, and also with his desire to see an aerial mail service established within the Empire. Referring to the aerial mail service inaugurated in the United States in May, 1918, the author quoted statistics showing that up to the end of 1922, a total distance of well over 5,000,000 miles had been flown, and over 160,000,000 letters had been carried at a total cost of 4,295,000 dols., while recent figures, he added, showed that 150,000 miles per month were being flown at a cost of 70 cents per mile. Assuming that a mail service could be conducted between London and Australia at a cost of 3*s.* per mile, and that a load of half a ton (39,000 letters) would be carried the whole distance, he said the average cost per letter would come out at less than 1*s.*, and the letter would be delivered in Sydney 10 days after posting—flying by day only; if night flying were perfected, the time occupied on the journey would be halved. With an air service established between London and India, Mr. Thomas pointed out, India could be reached in two or three days, and he added the suggestion that the saving in the cost of cables in the correspondence between the British and Indian Governments would probably form a considerable portion of the cost of running the air service. The rapid conveyance of bullion and financial documents by aeroplane was referred to by the author as another point of importance to commercial concerns, who he thought should also carefully consider the advantages offered by aerial transport in enabling officials to cover more ground in a given time than would be possible by any other means. The use of aeroplanes in connection with mining operations in inaccessible country, for the initial development of new townships, for aerial photography and surveying, and for assisting agriculture, were all touched upon in the paper, and the author concluded by expressing dissent from one of the conclusions in the report of the Advisory Committee on Air Mails, to the effect that the importance of an aeroplane service between this country and India would be reduced by the adoption of the Burney airship scheme. The whole question of air transport, Mr. Thomas remarked, was one of speed, and there were no signs that airships would even approach aeroplanes in this respect. This, of course, is perfectly true, but it must also be remembered that, in the present state of development of aircraft, the airship has the advantage with regard to night flying and would thus be able to maintain a higher average speed over a given distance than would be possible by an aeroplane flying only by day.

THE LATE MR. JAMES M. DOBSON.

WE regret to have to announce the death, which occurred at his residence, "Pescot," Longfield, Kent, on February 27, of Mr. James Murray Dobson, partner in the firm of Hawkshaw and Dobson, civil engineers, Millbank House, Westminster.

On leaving school Mr. Dobson served a period of pupilage of three years, namely, two years, from 1862–64, on the Holyhead harbour works, with his father, the late Mr. George Clarisse Dobson, and one year, in 1865, with the late Sir John Hawkshaw, F.R.S. He was subsequently in constant employment under Messrs. Sir John Hawkshaw, Son and Hayter,

from 1865 to 1885, engaged in the design and construction of harbour, dock and railway works. For the later 10 years of that time he was their chief assistant, and in that capacity had the direct charge of the construction of Maryport Dock. He then proceeded to Buenos Ayres to make the survey for the Buenos Ayres harbour works, and in 1887 was appointed chief engineer of those works, a position which he held until their termination in 1901.

On this occasion Mr. Dobson became a partner of the firm of Hawkshaw, Hayter and Dobson, of Buenos Ayres, established to carry out the harbour works in question with the consent of the Argentine Government, and a branch of the firm of Hawkshaw and Hayter, of London. From the death of Mr. Harrison Hayter, Past President Inst.C.E., in 1898, the name of the firm was changed, both in London and Buenos Ayres, to Hawkshaw and Dobson.

On completing the Buenos Ayres harbour works, which comprised two entrance basins, four large docks with their complement of warehouses, railways, and other equipment, Mr. Dobson returned to London, and was joint consulting engineer with the late Mr. J. C. Hawkshaw, Past President Inst.C.E., for the Madras Railway up to the termination of the contract with the Indian Government. He advised Messrs. S. Pearson and Son, Limited, with reference to their harbours at Coatzacoalcos and Salina Cruz in Mexico, and the Belfast Harbour Commission received his collaboration in regard to their graving docks. Mr. Dobson was also consulting engineer to the Crown Agents for the Colonies, for the Mauritius Government Railways, to the Midland Railway Company of Western Australia, Limited, and the West of India Portuguese Guaranteed Railway Company, Limited, for their harbour at Mormugao on the West Coast of India. Notwithstanding his age—he was 77 at the time of his death—Mr. Dobson was busy at his offices practically up to the last.

Besides being frequently consulted as an expert on dock and harbour construction, Mr. Dobson, in the course of his earlier training, acquired considerable technical knowledge in the design of locomotive engines, and was a member of the Sectional Committee on Locomotives of the British Engineering Standards Association from its formation.

He became an associate member of the Institution of Civil Engineers in 1873, and a full member in 1880. In November, 1911, he was elected a member of the council, and continued to hold the position until November, 1917, when he resigned. He read a paper on "Buenos Ayres Harbour Works" before the Institution in April, 1899, for which he was awarded a Telford Premium in the same year. Mr. Dobson had a wide circle of friends among our leading civil engineers by whom his loss will be deeply regretted.

"PRODUCTION COSTS IN THE ENGINEERING INDUSTRY."

TO THE EDITOR OF ENGINEERING.

Sir,—I have been reading with interest the leading article in your issue for February 29, in which you deal so pertinently with the subject of production costs. Engineers occupying big positions do not realise quite how much scope and need there is for concentration upon this subject. When the Institution of Production Engineers was founded, the suggestion was put forward that there were sufficient engineering institutions already, but so confident were the nucleus members of council that they went ahead, and we now muster a comfortable membership of keen works managers and production men who are profiting very much indeed by our activities. We still want more members, of course, and the papers which are presented to our Institution we feel quite sure might be studied with profit by every engineer and works manager in the country. The following are typical titles: "Jigs and Tools," "Machine Moulding Methods," "The Efficient Tooling of Automatics," "Modern Gauging Methods," "Commercialised Gear Cutting," "Fine Limits from the Foundry Standpoint," "Factory Planning."

My reason for writing to you is to extend on behalf of the Institution a cordial invitation to any of your readers who may care to attend our meetings. We find that when live production men have once paid us a visit they invariably become members and take as keen an interest as the rest of us. Our meetings are held at the Engineers' Club, Coventry-street, W.1, and are announced in the majority of the technical journals.

Very truly yours,
A. T. DAVEY, Hon. Secretary.
6, St. James's-square, Holland Park, London, W. 11,
March, 3, 1924.

TO THE EDITOR OF ENGINEERING.

Sir,—I am very pleased to see in your February 29 issue that you refer to the question of "Production Costs in the Engineering Industry." From personal contact with engineering firms, I have come to the conclusion there is certainly room for improvement on the lines that you suggest, and with a view to stimulating interest in this direction, I read a paper before the Institution of Electrical Engineers in February of last year. Among other subjects, I dealt with "Rate-fixing and Mechanical Processing" and "Costing"—two subjects which I consider need the most attention. I grant that there are so-called rate-fixing departments in most works, but in many cases these are not sufficiently organised. In costing, many works take costs as a whole, which makes it impossible to find out where excess costs really occur.

I trust that you will continue your propaganda in this direction in the interests of development of the industry.

Yours faithfully,
G. H. NELSON, Works Manager.
Attercliffe Common Works, Sheffield. March, 3, 1924.

"THE ELEMENTS OF THE LANCHESTER-PRANDTL THEORY OF AEROPLANE LIFT AND DRAG."

TO THE EDITOR OF ENGINEERING.

Sir,—In your recent articles on the circulation theory of wing lift the use of both complex algebra and of quaternion analysis raises the interesting question of the relations between them. It seems improvident to draw on the already overdrawn alphabet for symbols of operation when other familiar symbols are conveniently available, and for this reason I, while adopting Heaviside's notation in all other cases, prefer to denote the vector product by the multiplication sign $\times$ instead of by the letter V. The product of two vectors is thus defined by

$$a \times b = a\,b \sin(a\,b)\,n$$

where a, b are the scalar magnitudes of the vectors without reference to their direction, (ab) is the angle between them, and n is the unit vector perpendicular to both vectors, a, b, n forming a right-hand system.

Let i, j, k be three unit vectors forming a right-hand orthogonal system; then from the definition it is easily seen that the operator, $i\times$, applied to any vector in the $j-k$ plane, turns it through a right angle, and applied twice in succession, through two right angles, so that $i\times(i\times)$ applied to any vector in the plane may be replaced by the minus sign. In particular

$$i \times j = k,\ i \times (i \times j) = -j.$$

Hence any vector in the $j-k$ plane may be expressed by

$$x\,j + y\,k = (x + y\,i)\,j.$$

The expression in brackets, being the sum of a scalar and of a vector multiplier, is a quaternion operator in which the vector part is restricted to the $i-$ axis. Apply, in succession another operator of the same type, then by the rules of vector analysis,

$$\begin{aligned}(x_1 + y_1 i\times)\,(x + y\,i\times)\,j &= (x x_1 + y\,y_1 i\times\, i\times + \overline{x y_1 + x_1 y}\; i\times)\,j.\\ &= (x\,x_1 - y\,y_1 + \overline{x y_1 + x_1 y}\; i\times)\,j.\end{aligned}$$

Again, in complex algebra we have the fundamental operation of forming a product in the form,

$$\begin{aligned}(x_1 + y_1 i)\,(x + y\,i) &= x x_1 + y\,y_1 \times i^2 + \overline{x y_1 + x_1 y}\; i.\\ &= x\,x_1 - y\,y_1 + \overline{x y_1 - x_1 y}\; i.\end{aligned}$$

since $i^2 = -1$.

We may, of course, consider these expressions as algebraic operators applied to the "real" positive unit, and write them

$$(x_1 + y_1 i)\,(x + y\,i)\,(+1) = (x\,x_1 - y\,y_1 + \overline{x y_1 + x_1 y}\; i)\,(+1)$$

Comparing the final results it is seen that there is complete equivalence between the operation of complex multiplication and that of quaternion multiplication in the case where the vector part of the quaternion operator is restricted to the $i-$ axis, and the vector operand is restricted to the $j-k$ plane, while j is taken as unit vector along the "real" positive axis. The Argand plane then becomes identical with the $j-k$ plane, and the operator i applied to vectors in the Argand plane becomes identical with the operator $i\times$ applied to vectors in the $j-k$ plane.

It is obvious that repeated applications of the operator i or of $i\times$ thus restricted, being represented by successive rotations about the same axis, are commutative, while (finite) rotations about different axes are easily shown to be non-commutative. This is the fundamental reason for the great power of the methods of complex algebra, and for the disappointing limitations of general quaternion analysis. On the other hand, the less ambitious methods of vector analysis, corresponding as they do with physical realities, are coming more and more into common use by physicists and engineers, especially in Germany.

That the underlying principles are the same is seen from the fact that any expression in quaternion notation is expressible in vector notation.

Yours truly,
London, March 1, 1924. A. R. LOW.

THE MEASUREMENT OF AIR CONSUMPTION IN PNEUMATIC TOOLS.

TO THE EDITOR OF ENGINEERING.

Sir,—In the report of my contribution to the discussion on Mr. Wilson's paper in your issue of February 29, there are two points on which I desired to lay stress which do not appear. These are:—

(1) The great importance of measuring the air used by pneumatic tools. In this connection I instanced that on the Rand alone a saving of 130,000*l.* a year was effected by the first 100 meters of the general type shown in Fig. 3, which were sent out by the writers' firm, Messrs. G. Kent, Limited, of London and Luton. Incidentally these 100 meters were the first meters ever constructed for the special purpose of measuring the air consumption of pneumatic tools.

(2) The inaccuracy of any meter, such as that shown in Fig. 5, which attempts to correct for the complex pulsation error by simply fitting a non-return valve in a dashpot. The pulsation error cannot be accurately dealt with by such inadequate means.

Yours faithfully,
JOHN L. HODGSON,
c/o George Kent, Limited.
Eggington House, near Leighton Buzzard, Beds.
March 4, 1924.

"MECHANICAL ENGINEERING IN THE ARMY."

TO THE EDITOR OF ENGINEERING.

Sir,—This question is well worth the ventilation given in your leading article and Colonel Donohue's letter, as well as in General Sir Ian Hamilton's excellent little book, *The Soul of an Army*, and in his recent addresses. Before a really satisfactory solution is found, however, the whole subject of military engineering must be overhauled. The mechanical engineer, as a mere understrapper to the Corps of Royal Engineers or an assistant to Ordnance or Transport Departments, is not in his right place at all.

But I do not think the solution is to create a separate Corps of Mechanical Engineers, furnishing aid to the above corps when required. It is rather to be found in the conception that the work of several of the present departments is essentially mechanical engineering, and can only be effectively carried out if every officer in those departments is first and foremost a properly trained mechanical engineer. The Ordnance Corps, for example, is almost all mechanical engineering, and should be relieved of the supply of clothing and other non-mechanical stores which would be more appropriately handed over to the R.A.S.C.

Mechanical transport, on the other hand, should be amalgamated with railway operating and made a purely engineering service, and not a branch of food supply. Tanks and other forms of automobile artillery clearly belong to the R.A., who are very nearly akin to mechanical engineers in any case. Field defence works for infantry are entirely an infantry job, and in fact were carried out by the infantry in the late war, complicated by the absurd procedure of detailing infantry officers with their companies as "fatigue parties" to work under the direction nominally of an R.E. officer, but too frequently of an R.E. corporal. This system simply added needless labour and worry to the overworked infantry, for no apparent purpose but to maintain the privileged position of the sapper and to relieve the General Staff Officer of part of his proper responsibility.

The corps of R.E. would, under the above proposals, be employed on surveying, road, railway and bridge construction and maintenance, waterworks, and permanent fortifications and buildings. N.C.Os would be foremen and the privates would be navvies, bricklayers and joiners, very few of whom need be paid above infantry rates, nor be within the fighting standards of age and fitness.

There are, of course, many details which cannot be gone into in this letter, which is the outcome of a mechanical engineer's experience as an infantry officer and a brigade staff officer in France throughout 1915 and 1916, during which he came in personal contact with many examples of the waste and worry attendant upon the old system of treating the infantry as a combination of cannon fodder and general labourer, incapable of digging a trench without a sapper to instruct them, and to be employed on road mending during the brief intervals when they should have been training for battle, coupled with the almost total failure to utilise the mechanical engineering skill which probably formed a greater proportion in the British territorial and new armies than in any other of the belligerent forces.

It is worth noting, that when the Government eventually called large numbers of mechanical engineers as such from civilian work to war service, the work they did was hampered to a great extent by their lack of military knowledge, which defect was not made good by the conferment of military rank, and much ingenuity and public money were wasted upon appliances quite unsuitable for the conditions of war.

It is evident that the country cannot keep up in peace time a great and numerous Corps of Mechanical Engineers, and even if it did, efficiency would suffer from the lack of proper work to give them experience. The remedy seems to be to keep permanently the numbers necessary for the Regular Army, and to back these up with a large establishment of Territorials, who must be mechanical engineers actively engaged in the profession, and must be trained in the military aspects of the work they would do in war; and it is essential that such as show military aptitude should be eligible in war time for the higher staff and for commands. It is a great strain on the patriotic fervour of a man who is master of such a profession as that of the mechanical engineer, and has given his leisure, perhaps for years, to Territorial work, to find that in war he has little chance of showing his abilities, or of doing anything better than routine work under Regular officers of much less than his own attainments; and it is certainly not in the public interest.

Yours truly,
F. L. WATSON,
Major (Ret.), T.A., M.Inst.C.E., M.I.Mech.E.
Well House Foundry, Leeds, March 4, 1924.

"THE MEASUREMENT OF AIR FLOW."

TO THE EDITOR OF ENGINEERING.

SIR,—I feel compelled to differ strongly from your contributor, Mr. R. O. King, who in his article on "The Measurement of Air Flow," published on page 136 of your issue of the 1st inst., states :—

(1) "That the useful range of an orifice extends from a pressure difference of about 25 mm. of water to about 150 mm.

(2) "That there is uncertainty of the calibration data for values of h greater than 2 in. of water.

(3) That "nine or ten orifices would be required for a velocity range of from 1 to 500 ft. per second in a pipe."

The present writer, for instance, has calibrated orifices down to heads as low as 1/100th of an inch of water, and up to heads exceeding 2,000 inches of water; the heads being in every case measured to within one-third of 1 per cent. of accuracy.

He has published his results in various papers.* These results for steady flows are summarised in Figs. 1, 2, 3 and 4 above.

Fig. 1 shows the proportions of the orifices used.

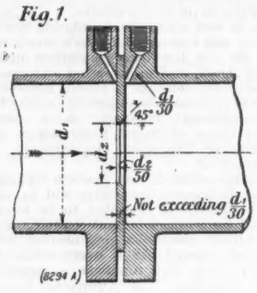
Fig. 2 shows the values of the coefficient of discharge, Ω for various values of d_2/d_1 under (what happens to be!) usual flow conditions.

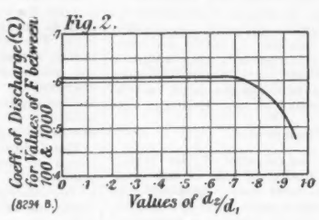
It will be seen on reference to Fig. 3c that the values of Ω differ from those given in Fig. 2 for values of the criterion $\sqrt{D}\,\rho/b_2\,\mu = F$,† which are appreciably less than 100, and also when the value of $(p_2/p_1)^{1/\gamma}$ is appreciably less than unity.

It is merely a fortunate chance that orifices used for air, gas and steam measurement purposes can usually be designed so that the value of F lies between 100 and 1,000; *i.e.*, on the part of the Ω, F, curve shown in Fig. 3B, where the value of Ω is practically constant.

The present writer was the first to point out that for the actual fluids commonly measured, and over the range of flows, and the densities and viscosities and pipe sizes commonly met with; the effects of viscosity and elasticity did not have to be considered together; and that practically the only portion of the Ω, F, or the Ω $(p_2/p_1)^{1/\gamma}$ curves that one had to consider in actual metering was the conveniently straight portion between the values F = 100 and F = 1,000.

The criterion $(p_2/p_1)^{1/\gamma}$, and for elastic flows is approximate only; no theoretically exact criterion being possible. It should be noted that even at the highest value of F plotted (viz., F. = 1,000) the value of p_2/p_1 is not appreciably different from unity.





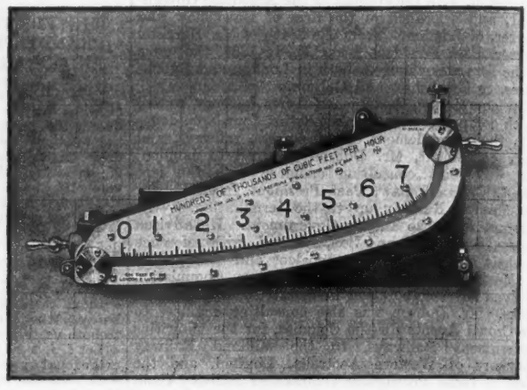


FIG. 5.

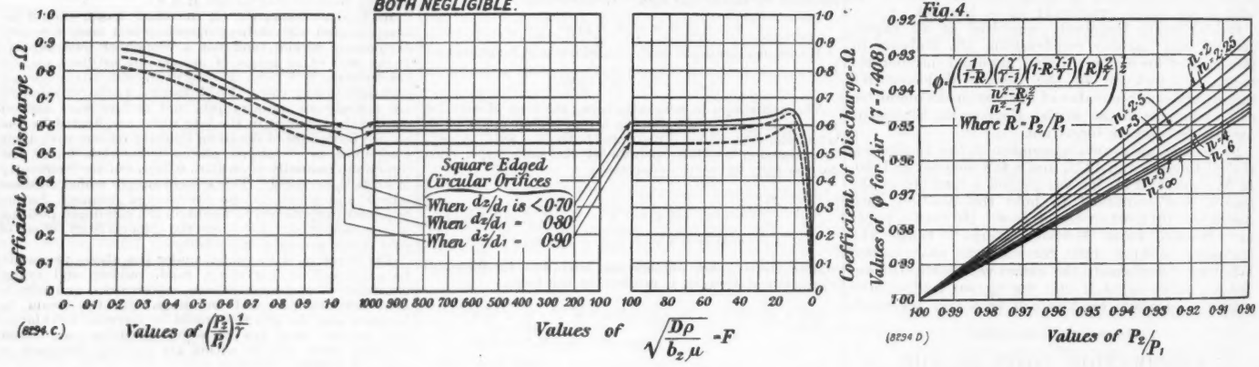


Fig. 3a. VISCOSITY NEGLIGIBLE.
Fig. 3b. VISCOSITY & ELASTICITY BOTH NEGLIGIBLE.
Fig. 3c. ELASTICITY NEGLIGIBLE
Coefficient of Discharge - Ω
Square Edged Circular Orifices
When d_2/d_1 is < 0·70
When d_2/d_1 = 0·80
When d_2/d_1 = 0·90
(8294 C.)
Values of $\left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma}}$
Values of $\sqrt{\frac{D\rho}{b_2\,\mu}}$ - F
Coefficient of Discharge - Ω

The discharge equation which should be used in connection with the values of Ω plotted is

$$Q = \frac{0{\cdot}669\ \Omega\ a_1}{(n^2-1)^{\frac{1}{2}}}\,[(p_1 - p_2)\,W_1]^{\frac{1}{2}}\,[\phi]\ \text{lb. per sec.} \qquad (1)$$

where

$$\phi = \left[\frac{\left(\frac{1}{1-R}\right)\left(\frac{\gamma}{\gamma-1}\right)\left(1-R^{\frac{\gamma-1}{\gamma}}\right)\left(R\right)^{\frac{2}{\gamma}}}{\frac{n^2-R^{\frac{2}{\gamma}}}{n^2-1}}\right]^{\frac{1}{2}} \qquad (2)$$

Values of ϕ for air for various values of n are given in Fig. 4.

The values of the various symbols used are as follows :

- Ω = Coefficient of discharge.
- p_1 = pressure on upstream side of an orifice or a nozzle in lbs. per sq. in. (abs.).
- p_2 = pressure on downstream side of an orifice or a nozzle in lbs. per sq. in. (abs.).
- R = ratio p_2/p_1.
- W_1 = weight of 1 cub. ft. of the fluid passing at the upstream side of the orifice (in lbs.).
- γ = ratio of the specific heats (= 1·408 for air).
- D = discharge in cubic centimetres per second.
- ρ = weight of fluid in grammes per cubic centimetre.
- b_2 = diameter of orifice, nozzle or pipe, &c., in centimetres.
- μ = viscosity in C.G.S. units.
- d_2 = diameter of the orifice in inches.
- d_1 = diameter of the main upstream of the orifice in inches.
- n = $(d_1/d_2)^2$.
- a_1 = area of main upstream of the orifice in square inches.

The curves shown in Fig. 2, and the portions of the curves in Fig. 3 which are shown in full lines, are amply covered by experimental results, and, for the values of F which lie between 100 and 1,000, can be relied upon to within ½ per cent., while the dotted portions of the curves show the values of Ω to be expected, when further experiments are made.

It should, however, be noted with reference to the values of Ω given in Fig. 2, that when the ratio d_2/d_1 is greater than, say, 0·7, the smoothness of the pipe in which the orifice is placed, and any inaccuracy in the measurement of d_1 have a considerable influence upon the value of Ω.

The values given in the figure are for pipes machined internally.

The writer has also, among others, developed instruments which enable measurements of the difference of pressure across an orifice to be accurately taken over a far greater range of values than the 25 mm. to 150 mm. of water referred to by Mr. King.

One such instrument (the Curved Tube Manometer) is shown in Fig. 5. This instrument, in which the gauge tube is curved so that an equally spaced flow scale is obtained, enables readings of the head to be taken within ½ per cent. of accuracy between heads of 126 mm. and 0·56 mm.; *i.e.*, over a flow range of 1 : 16. Three orifices used in conjunction with this instrument would therefore be ample to measure velocities in a pipe between 1 and 500 ft. per second.

This instrument was described in the Proceedings of the Aeronautical Society in 1914, and has been described on many subsequent occasions. It is an instrument that is now quite well known among air and gas engineers, and also to foundry managers, who use it for measuring the air supplied to cupolas.

Since it is possible to measure differences of pressure by means of such an instrument as the Curved Tube Manometer, at least as accurately as it is possible to measure an electric current, and since a 1 per cent. error in the measurement of the electric current when using the "hot wire" method involves a 4 per cent. error in the flow measurement, whereas a 1 per cent. error in the measurement of the difference of pressure when using the "orifice" method involves only a ½ per cent. error in the flow measurement, it is obvious that the hot wire method has very grave inherent disadvantages as compared with the orifice method.

Yours faithfully,

JOHN L. HODGSON, M.I.Mech.E.

Eggington House, near Leighton Buzzard, Beds.,
February 14, 1924.

SELL'S DIRECTORY OF REGISTERED TELEGRAPHIC ADDRESSES.—This well-known directory for the current year, published at the price of 45*s.* net, by Business Dictionaries, Limited, 8 and 9, Johnson's Court, Fleet-street, E.C.4, is now available. It gives the names, postal and telegraphic addresses, with telephone numbers of London and of United Kingdom business firms. The telegraphic address code words are arranged alphabetically in separate sections. Another section covers the firms under trades arranged alphabetically, there being also sections giving the titles and addresses of British journals, a building trades directory, telegraph tariffs to all parts of the world and other useful information. The book constitutes a handy business guide.

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* "The Commercial Metering of Air, Gas and Steam." Proceedings of the Institution of Civil Engineers, vol. cciv, Part II.

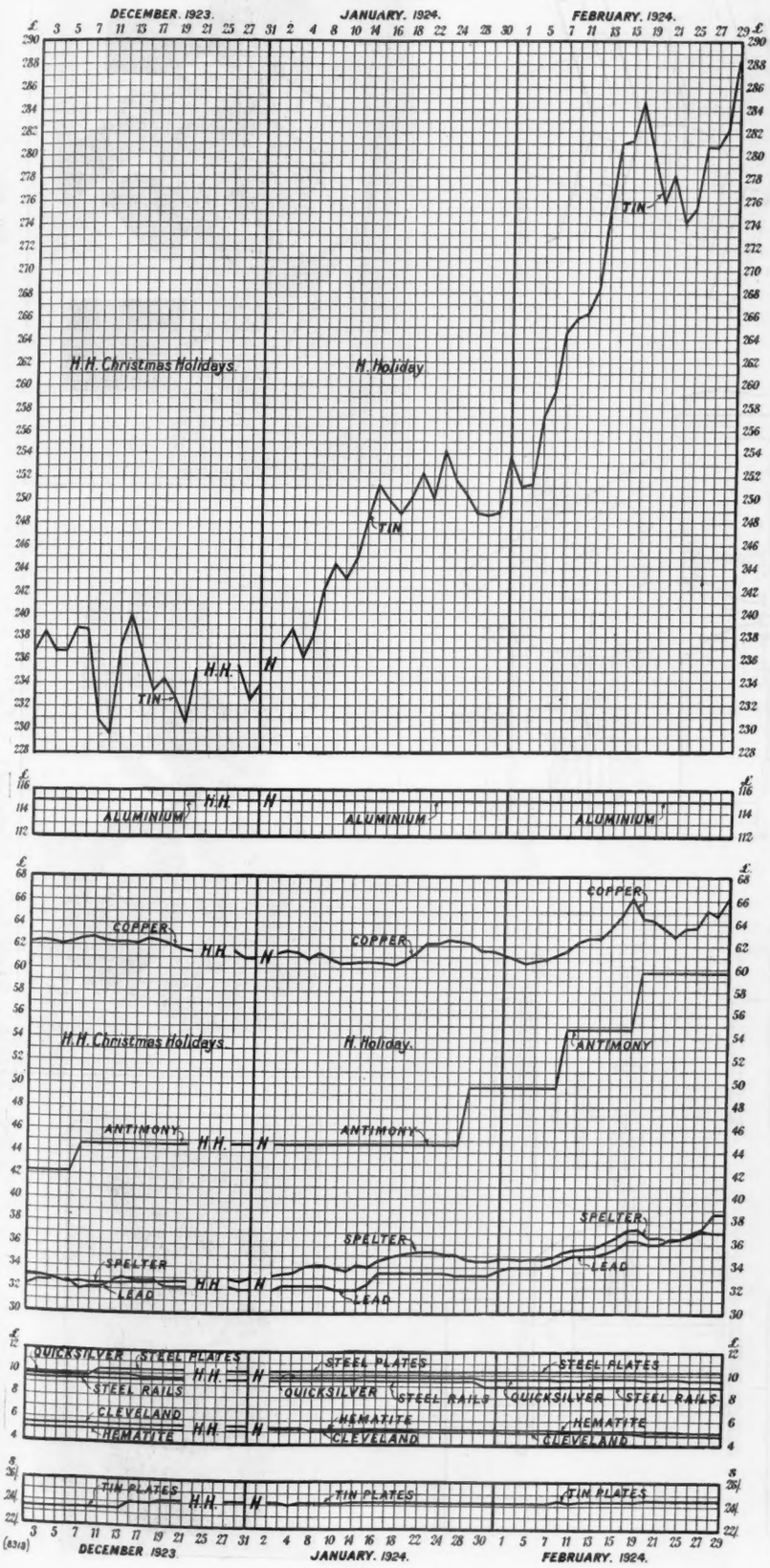
"The Metering of Steam." The Institution of Naval Architects, 1922, Figs. 9, 10 and 11, Appendix I.

Proceedings of the Institution of Civil Engineers, vol. ccx, page 272.

† The criterion $\sqrt{\frac{D\,\rho}{b_2\,\mu}}$ is a modification of the Reynolds' criterion $\frac{V\,b_2\,\rho}{\mu}$ (where V = the velocity of the fluid). This criterion, which has proved to be one of the most fruitful contributions to hydraulic theory of the past 50 years, was developed by Professor Osborne Reynolds (in 1883) in his search for a law of similarity to connect the flows of fluids of various viscosities and densities in pipes of various diameters. Its validity, so far as the flow in pipes was concerned, was demonstrated in a classical research by Stanton and Pannell (1910). It was next used (1914) by the late Lord Rayleigh to explain the "scale effect" in wind-tunnel experiments; and it was at Lord Rayleigh's suggestion that the present writer used it (in 1916) to correlate the results of his tests on the flow of fluids of various viscosities and densities through orifices and nozzles. It is now becoming recognised, both in this country and in America, as the standard method of plotting orifice and nozzle results.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



METAL PRICE DIAGRAMS.

NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates and for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which vary from 70 lb. to 80 lb. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

WATER SUPPLY TO BOMBAY.

INTERESTING work is now in progress for increasing the Bombay water supply from Tansa Lake, a distance of 55 miles. Two parallel lines of pipes, each 72 in. in diameter, are being laid from Tansa to Powai, whence they are formed into three pipes, two of them being 57 in. in diameter each, which continue to Bombay; the third, 60 in. in diameter, is laid to Ghatkoper and will be connected to the two existing 48-in. mains. The pipes will convey to Bombay 90 million gallons per day, and the arrangement provided is capable of expansion to 160 million gallons per day. The track along which the pipes are being laid and the tramway for their transport are carried out by the Tata Construction Company. The work involves the building of 150 masonry bridges and culverts, and about 70,000,000 cub. ft. of earthwork in excavation and embankment.

The steel pipes are manufactured and laid by Messrs. Braithwaite and Company, Limited, about 90,000 tons of steel being required to complete the work. The steel plates, $\frac{3}{8}$ in. thick, are rolled at the Redcar Works of Messrs. Dorman, Long and Company, where their edges are planed and their rivet holes drilled. The plates are formed into pipe lengths by Messrs. Braithwaite in a workshop they have erected at Mulund, near Thana, on the G.I.P. Railway. The manufacture of expansion joints, taper pieces, bends, branches, elbow outlets, manholes, &c., is carried out by Messrs. Braithwaite, at their West Bromwich works. A considerable portion of the work is therefore executed in India, close to the site of the pipe line, with Indian labour trained and supervised by European engineers. By shipping the plates flat a large saving in freight is realised. On arrival at Mulund the flat plates are rolled up into tube lengths; these are then hydraulically riveted longitudinally, and eight lengths are subsequently riveted together in sections of about 57 ft. for delivery at the site, where the sections are riveted one to the other by compressed air.

The laying of the pipe line has involved the construction of two new bridges at Kasheli, the existing bridges not being sufficiently strong. These new bridges are known as the Kasheli Bridge and Kasheli North Bridge. The work so far done in connection with the scheme, called the Tansa Completion Scheme, points to having the pipe line completely laid and put in service before the year 1926 is reached. The whole of the work is being carried out to the plans and under the supervision of Mr. H. J. Trivess-Smith, M.Inst.C.E., M.I.Mech.E., of the Water Department, Bombay Municipality.

"OPEN-HEARTH FURNACE LININGS.—The American manufacturers of refractory materials complain that the steelmakers do not co-operate sufficiently with them, says *Iron Trade Review*, Cleveland, Ohio. The emphasis laid by the former on the extent to which the question of design is associated with the life of refracting in open-hearth furnaces reflects a feeling that is prevalent in the steel industry itself. Steelworks' engineers agree that the design of these furnaces is susceptible of great improvement and admit that the high living charge for the open-hearth per ton of steel, as compared with the living cost of the blast furnace per ton of pig-iron, results to an extent from causes other than the finality of refracting. This matter of design is being studied constantly. What the steelmakers want is a brick that will withstand the existing working temperatures, a brick either basic or neutral, and having the physical strength to stand the stress and strain which it must meet in reserve. Various materials exist, but the difficulty has been in making them into brick. In the meantime, Silica brick, by reason of the abundance of silica, continue supreme for the basic open-hearth furnace, despite its acid character.

TRACTION ACROSS ROUGH AND ROADLESS COUNTRY.

(*For Description, see opposite Page.*)

Fig. 20.

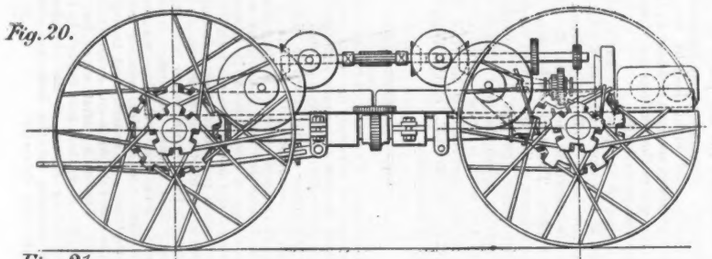


Fig. 21.

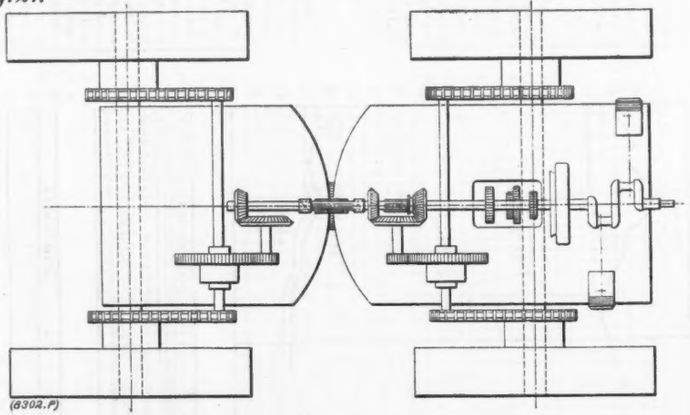


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Fig. 22.

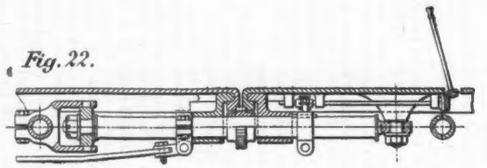


Fig. 23.

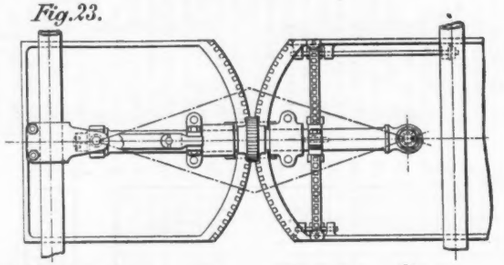


Fig. 24.

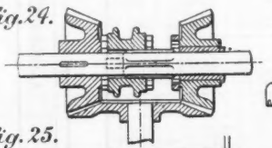


Fig. 25.

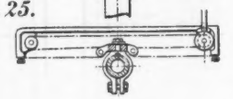


Fig. 26.

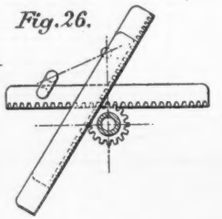


Fig. 27.

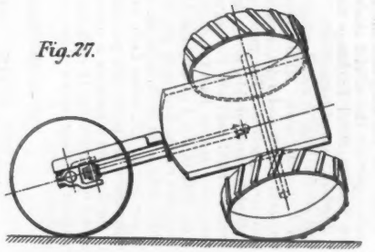
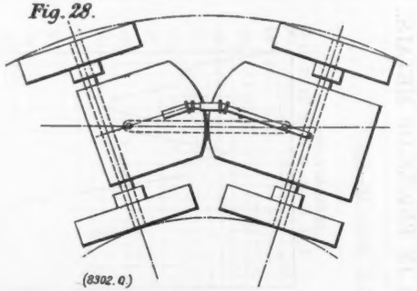


Fig. 28.



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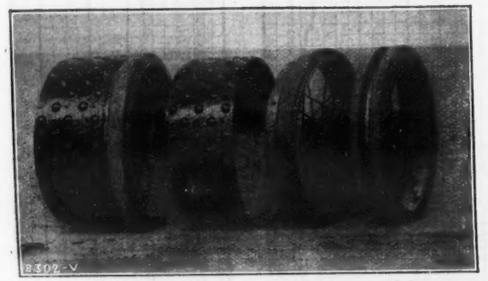


FIG. 29.

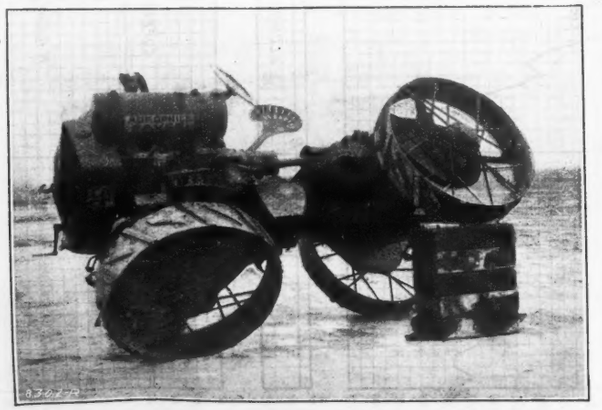


FIG. 30.

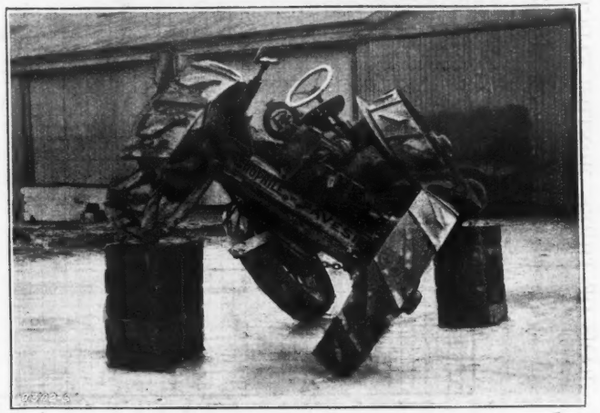


FIG. 31.

TRACTION ACROSS ROUGH AND ROADLESS COUNTRY.

FIG. 29.

FIG. 30.

FIG. 31.

TRACTION ACROSS ROUGH AND ROADLESS COUNTRY.

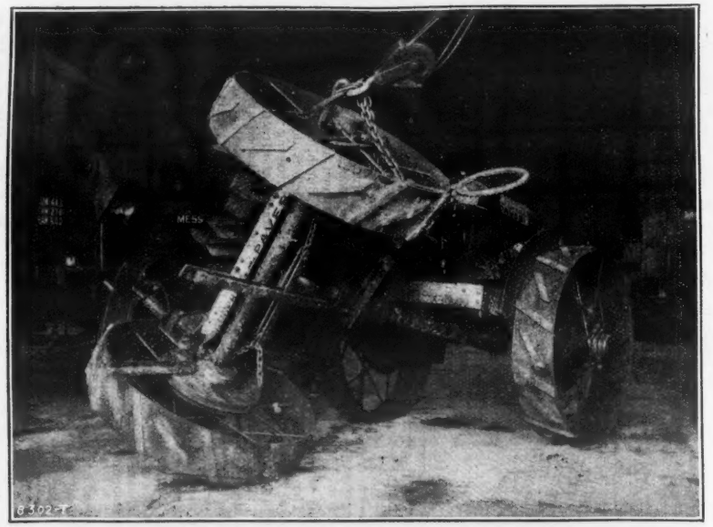


FIG. 32.

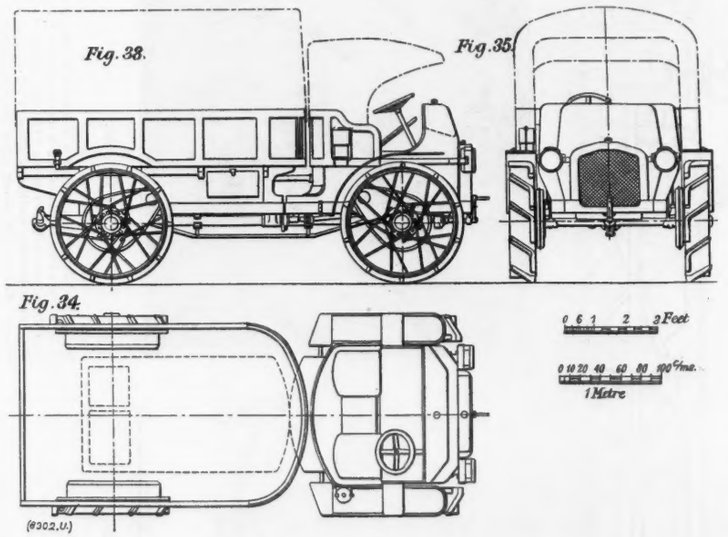


FIG. 36.

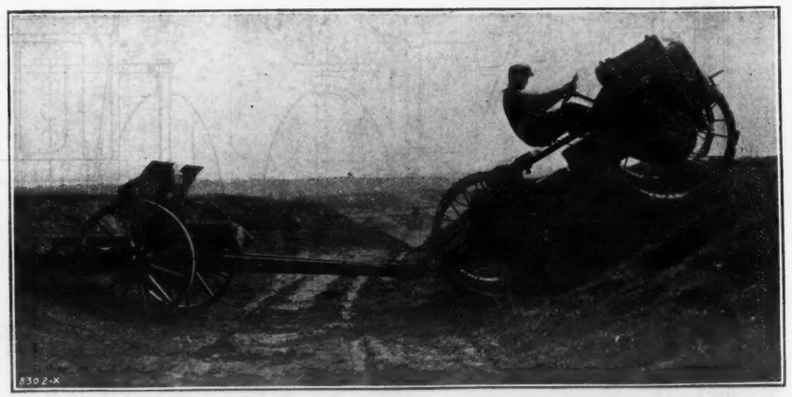


FIG. 37.

TRACTION ACROSS ROUGH AND ROADLESS COUNTRY.*

By L. A. LEGROS, O.B.E., M.I.Mech.E.

(*Continued from page* 286.)

The Pavesi Articulated Tractor (*Italian*).—This tractor which has been designed with a view to eliminating as far as possible, the difficulties that have been mentioned, deserves attention on account of the various constructional problems of which it gives a solution. The following is a brief description of the machine, Figs. 20 to 32: The chassis is in two parts connected by a cylindrical member, which is pivoted to the front part on a vertical axis and to the rear part by a universal joint; this arrangement allows each half to move relatively to the cylindrical member; on the centre of this is a pinion capable of revolving on it and gearing with toothed racks, formed on the undersides of each half of the chassis, the arrangement being virtually a double bevel gear; this gear co-ordinates the movements of the front and rear halves of the chassis. Steering is effected by means of the ordinary wheel and inclined shaft, which drives through bevel gears a shaft parallel to the axis of the front half; the shaft carries a chain-wheel and by means of a double purchase arrangement pulls the central member round in either direction about its vertical pivot; this movement causes the rack on the front half to drive the pinion and thus causes a corresponding movement of the rear half of the chassis.

Considering the front half of the vehicle as remaining horizontal any movement up or down of one of the rear wheels causes the rack to move in gear with the pinion and slightly advances the position of a wheel that is descending and retards that of a wheel that is rising; this tends to diminish the effective gradient in climbing a small obstacle. The gearing with the central pinion is assured by the two retaining brackets, of which that

* Paper read before the British Section of the Société des Ingénieurs Civils de France on February 20, 1924.

TRACTION ACROSS ROUGH AND ROADLESS COUNTRY.

Fig. 38.

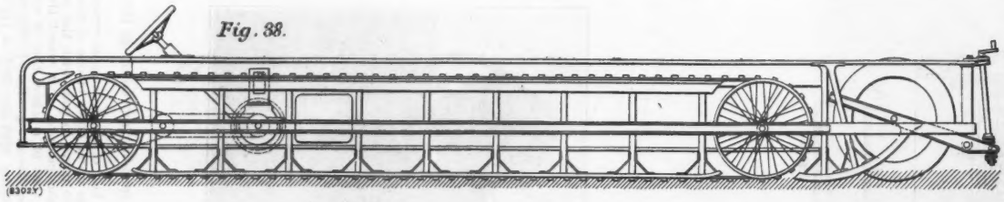


Fig. 39.

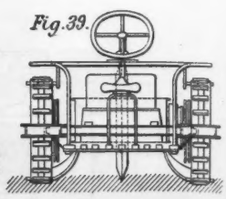


Fig. 40.

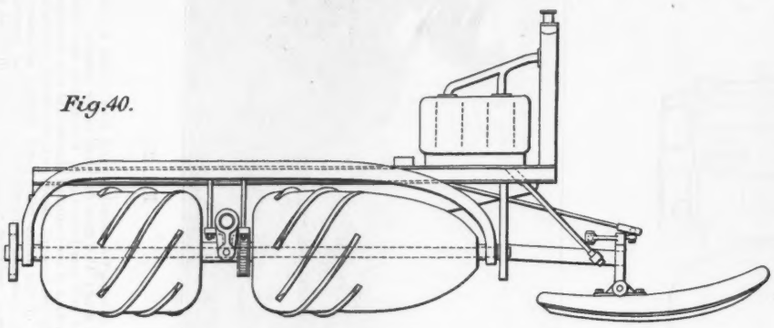


Fig. 41.

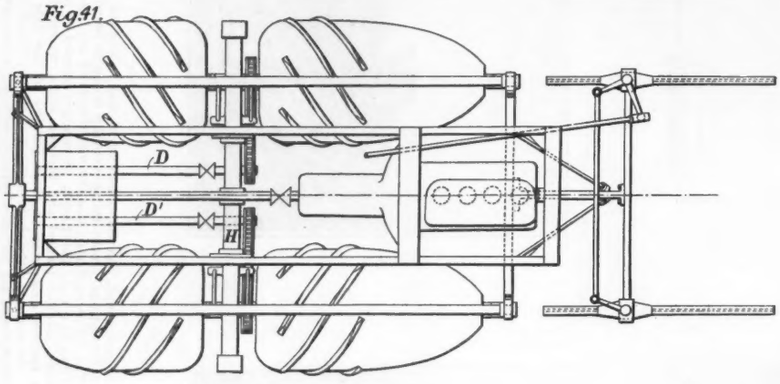


Fig. 42.

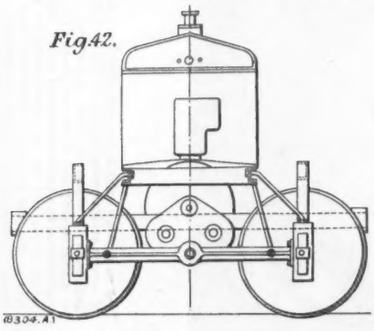


Fig. 43.

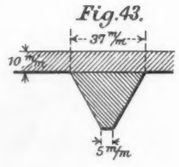
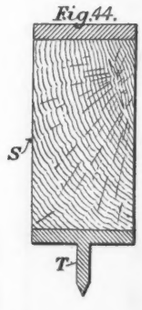


Fig. 44.



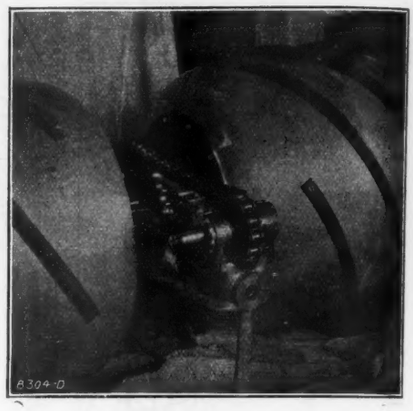


FIG. 45.

in front is made fast to the central member, whereas that at the rear is free to revolve on it, but is secured against endway movement by a fixed collar. These brackets have bearing surfaces which run on the upper machined internal faces of the chassis halves.

The motor has two horizontal opposed cylinders 130 mm. bore by 170 mm. stroke, and is capable of developing 30 h.p. on petrol at 950 revolutions per minute. It drives through a clutch to a two-speed change-gear box; the shaft from this carries a bevel-wheel running free, but capable of being engaged by a dog-clutch which can alternatively be engaged with the pinion keyed to the rear coaxial shaft; this forms the reversing gear. The secondary bevel wheels and shafts drive the two differentials and the shafts from these drive the wheels by chains. There is no intermediate differential. The two forward speeds are approximately 2 to 3 m.p.h. on first gear and 3·5 to 6 m.p.h. on second gear; the speeds are the same in reverse. The reduction ratios are 35·5 to 1 on second gear and 84·8 to 1 on first gear. The driving wheels are 1·2 m. (about 4 ft. diam.) and the width of tread is 10 in.; the wheel base is 2 m. (about 6 ft. 7 in.); the track measured from centre to centre of the treads of the wheels is 1·45 m. or about 4 ft. 9 in.; the under clearance is 18·5 in. The weight of the tractor is 3 tons, distributed to give 60 per cent. on the front wheels and 40 per cent. on the rear wheels at rest. The drawbar pull on the first gear amounts to 2·4 tons or 80 per cent. of the weight. The maximum inclination of the axles to each other in plan is 25 deg. (Fig. 27), giving a turning circle of about 29 ft. radius on the outside, or 23 ft. 6 in. on the inside. If one of the back wheels is raised, the front being kept level, the balance is reached at 58 deg. to the horizontal (Figs. 27 and 30); for the front half the balance is at 47 deg. The packing of a front and a back wheel on each side to the height of 2 ft. 1 in. is shown in Figs. 30 and 31, the inclination of the axles to each other in front or back aspect being 52 deg. These illustrations show the capacity of the machine for overcoming obstacles of the ground.

The wheels are of steel of light tangent construction; they can be fitted with spuds or rubber blocks according to the nature of the ground or road to be run over. From the diagrammatic drawings many details have been omitted, such as the springing arrangements and the eccentric gear for enabling the wheels on one side to be raised for ploughing when two wheels run on the land and the other two in the furrow.

The Pavesi Lorry.—This vehicle (Figs 33 to 36) is constructed on the same principle as the tractor; it is capable of carrying a load of 2·5 tons, its weight empty is 3·5 tons; its wheelbase is 2·8 metres (about 9 ft. 2 in.); and the mean width of track 1·70 m. (about 5 ft. 7in.). The mean turning radius is about 11·2 m. (about 36 ft. 8 in.). For use on desert sand the wheels can be fitted with extension tyres increasing the width up to a total of about 20 in., as shown in Figs. 29 and 36, the latter showing a tractor crossing the dunes. The illustration (Fig. 37) shows the Pavesi tractor climbing a steep gradient.

TRACTION ACROSS SNOW.

Before 1909 Mr. B. Hamilton constructed a machine for polar expedition work, but as the result of trials made in the Alps it was found unsuitable for the difficulties.

The Wolseley Motor Sleigh was constructed in 1909 with chain tracks for use in Captain Scott's antarctic expedition; these sleighs were used in the earlier portion of the journey, but abandoned in the final dash for the pole*. Three of these motor sleighs were constructed, fitted with four cylinder air-cooled motors developing 12 h.p. at 1,100 r.p.m. The bearing length of track was 9 ft. 6 in., the overall length was 14 ft. and the width 3 ft. 6 in. There were two speeds of 1·75 and 3·5 m.p.h. respectively. The motor sleigh could climb a gradient of 1 in 2 (about 27 deg.).

A gasoline sled has been illustrated in American journals† and brief descriptions given of the sled, which is shown diagrammatically in Figs. 38 and 39; it was intended to replace dog sleds on the Yukon trail. This sled according to the description is 25 ft. long, weighs 890 lb. and has carried a load of 1,500 lb. 100 miles a day with a maximum speed of 30 miles per hour; its radius of action is stated to be 600 miles. The Chief of the postal service and the Dean of Fairbanks University of Alaska, in replying to inquiries stated that the machine could not be traced as having actually worked in Alaska.

The Armstead Snow Motor.—A machine was constructed in 1920 in America known as the "Snow Motor," the invention of Mr. F. R. Burch, of Seattle, in the State of Washington. This vehicle is designed on very original lines and is intended for crossing snow and ice. Instead of wheels or chain-tracks, the tractor is mounted on two pairs of drums, projectile shaped at the front ends and having their axes parallel to the axis of the tractor; the object of the projectile shaped end is to press down the snow and prepare the surface for traction, which is effected by helical threads of truncated triangular section attached to the drums. There are six threads spaced 9 in. apart giving a pitch of 4 ft. 6 in.; the inclination of the threads to the normal is about 29° 30′; the right-hand drums carry left-hand threads and the left-hand drums right-hand threads, and in forward gear these run outwards on the under side; this arrangement neutralises the lateral forces.

The tractor, Figs. 40 to 47, is driven by a four-cylinder petrol motor, 4½ in. bore by 6 in. stroke of 32 h.p. (American rating) at a normal speed of 1,200 r.p.m. The motor drive taken through a clutch goes through a gear

* See Proc. Inst. Mech. Eng. 1918, pages 127–9

† Popular Mechanics, Chicago, May, 1919, page 702. In this article it is stated that the load of the dog sleigh is 650 lb., and the distance travelled 25 miles per day.

TRACTION ACROSS ROUGH AND ROADLESS COUNTRY.

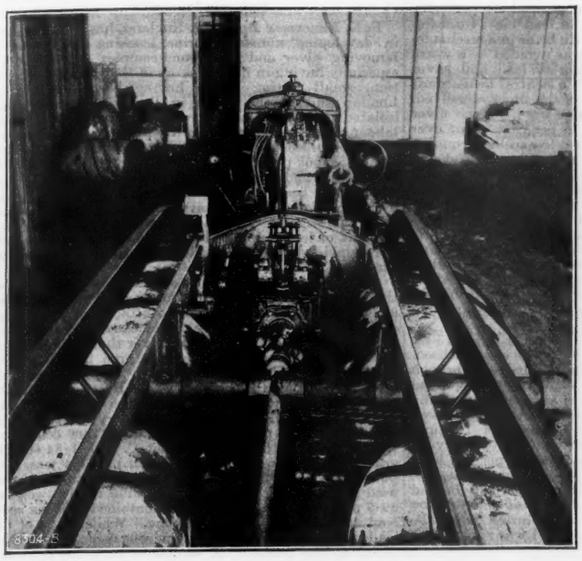


FIG. 46.

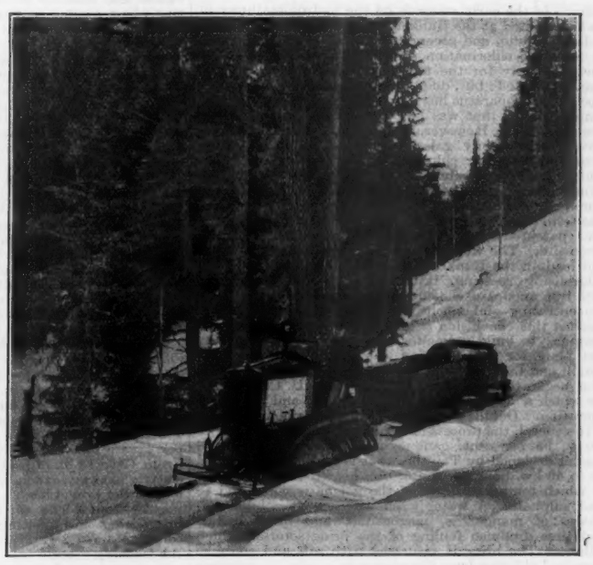


FIG. 47.

box, giving three forward speeds of 1·95, 3·90 and 7·8 m.p.h. respectively; the reverse gives 1·67 m.p.h. The shaft from the main gear box enters a second gear box at the rear of the chassis where the power is transferred to two secondary shafts DD′ running in opposite directions but parallel to the axis of the car and coming nearly to the centre of the car, where they are coupled by cardan joints to the short shafts that carry the driving chain pinions. These short shafts run in bearings in a casting that can rotate at one end in bearings, carried by brackets fixed to a central tubular cross-member H, and at the other end in brackets secured to the side-members of the chassis and carrying the cross-member. These pivoting castings also carry the main bearings for the drum axles. Each axle carries a chain-wheel adjacent to the bearing and has two other bearings at the ends, which are carried by a curved side frame attached to the casting, which turns on the brackets so as to enable the drums to accommodate themselves to irregularities of the snow or other surface; the curved frame serves to distribute the weight of the chassis on the axle, the lateral thrusts are taken by slide blocks fitted in two pairs of slotted frames, front and rear, and secured to each other by cross-members.

Steering is effected by means of runners 4 ft. 7 in. long by 2 in. wide and 4 in. deep, shod with T-iron bevelled to a narrow edge on the under side. Each runner is pivoted horizontally by a pin joint to the lower end of a steering arm, operated through the ordinary Ackermann gear by a steering wheel of the usual type.

The weight of the machine light is given as 5,000 lb. and loaded 5,500 lb.; the width of the track, centre to centre of drum is 4 ft. 7·5 in.; diameter of drums at the bottom of the screw is 30 in.; the screws are of equilateral triangular section 1·44 in. side, the vertex being machined to a cylindrical surface and 0·19 wide. The sinkage in soft snow is stated as 8 in., giving an average pressure of about 2 lb. per square inch. The makers state that with this sinkage resistance of the snow to traction is sufficient to stall the motor, and that the same result is obtainable on ice. The tractor is also stated to be able to run on a glazed sidelying inclined surface. The maximum tractive effort is given as 4,000 lb. on loose powdered snow and 3,500 lb. on ice that is 73 and 63 per cent., respectively, of the weight. With a total load of 7 tons of concentrates a 14-mile run in Idaho is stated to have been made at an average speed of 7 m.p.h., and a maximum speed of 23 m.p h. has been made on ice. The snow motor is now being manufactured in America for winter work in mining and lumber districts.

The tractors previously described are specially designed for rough country or for snow. The next vehicle to be considered is capable of running over rough ground, marsh sand and snow.

(To be continued.)

HYDROMETALLURGY OF LEAD.*

By OLIVER C. RALSTON, Berkeley, California.

(Concluded from page 252.)

TINTIC-STANDARD MILL.

At Harold, Utah, in the eastern part of the Tintic district, the Tintic-Standard Mining Company is engaged in mining a large deposit of ore, part of which can be shipped directly to the smelters and part of which must be milled. Because of its oxidised condition, mechanical concentrating methods are not efficient and leaching methods have been adopted, using the Holt-Dern process as developed in the mill of the Tintic Milling Company. The ore has the following average partial analysis:—

Au, ounces per ton	0·025
Ag, ounces per ton	17·0
Cu, per cent.	0·35
Pb, per cent.	4·0
SiO_2, per cent.	56·0
$Fe_2O_3 + Al_2O_2$, per cent.	16·3
CaO, per cent.	0·33
Zn, per cent.	0·12
S, per cent.	2·5

Two hundred tons of this ore are treated daily by pulverising, mixing with coal dust and salt, and then roasting in a blast roaster of the Holt-Dern type. This chloridised ore is then placed in wooden leaching vats and treated with a strong brine, which dissolves the silver, copper, gold, and lead. To get a good extraction of gold requires the use of a strongly oxidising solution containing ferric chloride, but in this case not enough gold is present to warrant the using of such solutions. A barren solution and a wash solution follow the original leaching solution in treating the ore. The metal extractions claimed, based on smelter settlements, are 82 per cent. silver, 40 per cent. copper, and 40 per cent. lead; steps are being taken to improve the lead practice on account of the value because of enhanced metal prices, as the roasted ore has 85 per cent. of the lead in brine-soluble form. The pregnant solution is pumped to towers where it passes the roasting gases and is thus acidulated with sulphuric, sulphurous, and hydrochloric acids from the roaster. It is then passed to the silver precipitators, where copper is used to displace the silver from solution. After this, the solution is run over scrap iron in launders, or long boxes, and the copper recovered. Then the solution is heated by live waste steam to 75 deg. C. and passed to launders containing baled tinplate scrap from local canneries. One pound of iron precipitates 2·6 lb. of lead and the composition of the lead precipitate is as follows: silver, 2 to 5 oz. per ton; copper, 3 to 5 per cent.; lead, 78 to 83 per cent.; iron, 3 per cent.; insoluble, 3 per cent.; arsenic, 0·7 per cent.; and zinc, 0·7 per cent.

Heating the solution has the disadvantage that the steam dilutes it, thereby greatly reducing its lead-dissolving powers. However, for ordinary dense iron, it is absolutely necessary to heat the solution to obtain a utilisable velocity of precipitation. Sponge iron was tried, being placed in the launders; while it functioned very well, the sponge lead clogged the precipitating trough, and not all of the iron was used up. However, because of its success in the mill of the Tintic Milling Company, sponge iron is again being considered. Inasmuch as the lead has been a by-product, recovered incidentally to the extraction of silver, the cost of recovery has merely been calculated on the precipitation and marketing expenses, neglecting a proportionate share of the grinding, roasting, and leaching; on this basis, the lead cost 1·6 cents per lb. on cars ready for shipment to a smelter. On this basis, the cost of extra plant for recovering the lead was amortised very quickly, and the operation had been on a profitable basis ever since. By preparing a cleaner lead precipitate and smelting it into bars for direct sale to the lead-consuming market, more would be realised than shipping the lead precipitate to a lead smelter merely as a rich-lead ore. Improvements both in extraction and grade of precipitate are being investigated

PLANT OF TINTIC MILLING COMPANY.

This was the first successful chloridising, roasting, and leaching mill in the Tintic district and followed a similar mill built at Park City by Holt and Dern. It is located at Silver City, Utah, and has been treating oxidised ores from several mines of the Knight and Dern interests for nearly eight years. Its capacity is 200 tons daily, but recently, because of the dwindling ore supply, only about 100 tons daily have been treated, and the silver content is now only 7 or 8 oz. per ton. Present operation is therefore intermittent. The pulverised ore is mixed with coal dust, pyrite, and salt and blast-roasted in Holt-Dern shaft roasters. The gases from the roasters are passed up a scrubbing tower supplied with pregnant solution in order to give up any acid formed in the vapours, and thereby acidify the solution so that better precipitation of silver and copper can be obtained. The roasted ore is collected in round wooden leaching vats and treated first with a solution low in silver and other metals, and is then passed to precipitation. Then it receives a wash by barren solution from the precipitation launders, and, finally, a water wash to recover salt. Since starting to recover the lead from them the solutions have been raised by the addition of salt from 22 deg. Bé to 27 deg., with a corresponding increase in the amount of lead from 4·7 to 10 gm. per litre, at ordinary temperatures. No attempt was made to purify the brines to increase their dissolving power for lead, nor has sufficient brine to extract all the lead been used.

The interesting part of the Tintic Milling Company's mill is the use of sponge iron for precipitation of the lead. Silver and copper are precipitated first on scrap iron, more or less as at the Tintic-Standard Mill; then the solution passes to several long launders with false bottoms, on which a 4-in. layer of sponge iron is spread. Cold solutions are completely precipitated in passing slowly down through this layer of sponge iron. The sponge iron is made from a low-grade iron ore mined locally and containing small amounts of silver, which is mixed with an equal weight of coal slack and heated to about 950 deg. to 1,000 deg. C. in a continuous rotary kiln developed by the Northwest Experiment Station of the Bureau of Mines (Seattle). The coal prevents any reduced iron from re-oxidising, and a small 27 ft. by 3 ft. kiln is producing 3 tons of sponge iron daily (the amount required by the mill. The resulting precipitate contains 20 per cent. iron and 40 per cent. to 60 per cent. lead, and a large amount of insoluble and other material from the original iron ore, nevertheless acceptable to the lead smelter. The successful commercial production of sponge iron was almost coincident with the production of 6 tons daily by the Chino Copper Company, with the Thornhill process, for the purposes of copper precipitation. The use of sponge iron from lead precipitation had been experimented with, for a number of years, by others, notably, H. R. Hanley, at Kennett, Calif., in 1917 and 1918, but the Silver City work was the first attempt at commercial operation.

Why sponge iron should be so efficient at ordinary temperature, in comparison with dense iron, is difficult to explain, unless it is because of the very much

* Abstract of a paper read at the New York meeting, February, 1924, of the American Institute of Mining and Metallurgical Engineers.

larger surface exposed. Sponge iron acts fairly efficiently at 30 deg. C., whereas dense iron, in the form of detinned light tinplate scrap, requires at least 75 deg. C.

BUNKER HILL AND SULLIVAN LEACHING PLANT.

Some of the early research on the hydrometallurgy of lead originated at the Bunker Hill and Sullivan plant, in Kellogg, Idaho, and several years' work has been done. At first, the chlorination process of John L. Malm, intended mainly for the treatment of complex sulphide ores, was tested; but, due to several operations for which mechanical apparatus has not been developed and to the simple-lead ore that was proposed for treatment, it was later dropped. However, during this work it was discovered how easily galena could be sulphated either during oxidising or chloridising roasting and also that lead sulphate was soluble in strong brines. Later, the brine-leaching and electrolysis process developed by the Bureau of Mines at its Salt Lake experiment station was tested at Kellogg under the direction of C. L. Larson, who patented the sequence of operations that was successful. The work of Larson showed that the silver and lead in the Bunker Hill ore could be extracted by chloridising roasting, brine leaching, and electrolysis with iron anodes as cheaply as, or more cheaply than, by concentrating and smelting. However, before he had reached this conclusion it had become necessary for the company to build a smelter and shortly afterwards the test plant for lead leaching was burned. It was later rebuilt and Larson's work was continued by W. G. Woolf, who began to test a modified process of U. C. Tainton, for which a 50-ton pilot plant was built and is now in operation. Details of Tainton's process are not available.

In general, the process is to roast the simple galena ore (80 to 95 per cent. gangue) in an electrically heated roaster designed by Tainton, that is expected to expend 30 to 50 kw.-hour per ton of ore, heated to 500 deg. C., at which temperature all of the galena is converted to lead sulphate. A water wash will remove soluble sulphates of manganese, magnesium, and other metals and thus diminish fouling of the brine solution which follows. The brine is saturated with salt and contains dissolved chlorine from the electrolytic cells, the purpose of the chlorine being to attack any unroasted galena but mainly to take silver compounds into solution as silver chloride. The brine is applied in agitators, thickeners, and a wood-lined Burt filter, which allows displacement of the brine from the filter cake by water. Calcium chloride is introduced in amounts sufficient to precipitate all sulphates from solution as calcium sulphate and prevent fouling of the solution. The lead and silver are precipitated from the brine. The sponge lead does not adhere to the cathodes but floats out of the cell with the brine and is collected and pressed into cakes ready for melting. The chlorine collected in the anode compartments dissolves, in part, in the solution, and the remainder is absorbed in a scrubbing tower, producing calcium chloride and hypochlorite for returning to the circuit. It makes possible 90 to 95 per cent. extraction of the silver and 95 to 98 per cent. of the lead, without the necessity of a chloridising roast.

PROCESS OF F. N. FLYNN.

The late F. N. Flynn, in conjunction with G. D. Van Arsdale, patented a process for treating products containing lead sulphate and was actively engaged in promoting a modified brine-leaching and electrolysis process in which a diaphragm cell was used and ferric chloride was formed at the anodes, with simultaneous depolarising of the anodes. This ferric chloride was reduced to ferrous chloride by the addition of calcium-sulphate liquor made outside of the circuit. Enough lime was also added to precipitate any excess of iron that accumulated in the solution, and to remove sulphates resulting from the dissolution of the lead sulphate. The lead-sulphate material or ore was merely treated with a sodium-chloride brine containing ferrous chloride. The ferric chloride was not utilised for its oxidising power on any lead or silver minerals. Therefore, the process was of value principally for recovering lead and of less value for silver-bearing materials, except where the silver had already been converted to brine-soluble form.

EXPERIMENTS ON KENNETT ZINC-PLANT RESIDUE.

Early in 1918, the U.S. Smelting, Refining and Mining Company carried out tests of brine leaching of their electrolytic-zinc plant residue at Kennett, Calif., which had the following average analysis: 0·68 per cent, Bi, 1·3 per cent. Cu, 11·92 per cent. Pb, 8·3 per cent. Zn, 0·35 per cent. Cd, 9·7 per cent. Fe, 6·5 per cent. S, 4·4 per cent. CaO, 27·1 per cent. water, 0·05 oz. Au and 6·3 oz. Ag per ton. This work was under the direction of H. R. Hanley. It was found that 85 to 86 per cent. of the bismuth, 90 to 94 per cent. of the lead and 40 to 50 per cent. of the silver dissolved directly in the acidified brine. Sponge iron was found to be an efficient precipitant of the lead. Precipitation on scrap iron was complete only after two hours' tumbling of the solution and iron in a barrel and was discarded as non-commercial.

SEMI-COMMERCIAL PLANT AT TRAIL, B.C.

Late in 1918, the Consolidated Mining and Smelting Company, at Trail, B.C., built a semi-commercial test-plant for treating tailing from its electrolytic-zinc plant. It was constructed near the tailing heap and also contiguous to the electrolytic-lead refinery so that the brine, after being loaded with lead, could be run to cells in the refinery and the lead recovered. About 15 tons of zinc-plant residue were treated daily and about 25,000 dols. was spent in testing the process. Brine leaching, followed by electrolytic precipitation with cast-iron anodes weighing 500 lb. each, was the process tested. Wooden tanks and pipe were used and caused considerable trouble from leakage when the wood was shrunk by the warm brines. The technical aspects of the process were very satisfactory, as practically all the lead in the material and much of the silver could be dissolved; but it was determined that the process would be more economical than smelting only when the residue contained less than 18 to 20 per cent. lead, whereas the zinc plant residue at that time contained 24 per cent. lead. The residue is still treated in lead blast furnaces.

The solid material was pulped with brine in a mechanically agitated tank (air agitation was avoided as a warm solution was desired) and solution of lead and silver was effected in 45 minutes. With a neutral brine, most of the lead, but only 50 per cent. of the silver, dissolved. By adding 1 to 2 gm. sulphuric acid per litre, the silver extraction could be increased to 78 per cent. For over a month, early in 1919, the plant was in excellent running order and made a 93·8 per cent. extraction of lead and 75·8 per cent. extraction of silver. The leached mixture was then run from the batch agitator to a 40-ft. Dorr thickener, where about 50 sq. ft. of settling surface per ton solids per 24 hour was found necessary. The overflow contained 9 to 10 gm. lead and 1 to 2 gm. sulphuric acid per litre. Silver was precipitated with scrap iron contained in launders and the resulting brine was then pumped to the electrolytic plant. The settled slime from the Dorr tanks was filtered in American disc filters without much washing, so that brine containing 150 lb. of salt was left in each ton of residue.

In the electrolytic-tank room concrete cells 7 ft. 3 in. long by 2 ft. 6 in. wide, and 5 ft. deep were utilised, leaving room below for a loose porous bottom through which air could be introduced to shake the sponge lead off the cathodes, 25 to 30 cub. ft. of air per minute being blown in. Iron anodes and cathodes were used, spaced 1·5 in. apart and with a current density of 15 amp. per square foot the potential drop was 1·0 to 1·5 volt. From 12 to 15 lb. of lead were precipitated per kw.-hour electric energy expended and iron consumption was 0·3 lb. per pound lead. Each cell produced 250 lb. lead per 24 hour. The sponge lead was best handled by briquetting and melting. The tail solution from the cells contained 2 gm. lead per litre, and was returned to the leaching plant.

An analysis of the solution after 14 cycles showed 191 gm. chlorine per litre, 27 gm. iron, 62 gm. sulphur (as sulphates), 2·3 gm. lead, and 5 gm. zinc. It was then purified by addition of milk of lime, leaving 154 gm. chlorine, 9·6 gm. sulphate, trace iron, trace lead, and trace zinc. Concrete construction seemed to be preferable to wood, as it did not shrink. Total costs of operation per ton, including the salt loss, were expected to be slightly less than 5 dols. on 15 per cent. lead material.

GREAT FALLS EXPERIMENTS.

Late in 1919, the Anaconda Copper Mining Company tested the same process for treating the electrolytic-zinc plant residue. Practically, the same conditions as had been used at the Salt Lake experiment station were adhered to. Suitable apparatus was set up in the old electrolytic-copper refinery in order to have electrolytic tanks for recovery of the lead. The normal zinc-plant residue contains 14 per cent. zinc, 12·3 per cent. lead, and 25 per cent. water but the material available at the time contained over 40 per cent. water and seriously diluted the brine. Leaks and the absence of suitable filtering equipment caused the use merely of settling tanks to separate the solution from the ore, followed by repulping with wash water; the loss of salt under these conditions were 318 lb. per ton. From 14 to 15 hours of settling gave a clear overflow liquor.

In all, about 7,788 lb. of lead sponge was recovered, representing a recovery of 93·7 per cent. of the original lead; 60 per cent. of the silver was soluble in neutral brine, and 90 per cent. in acidified brine. The sponge lead contained 25 per cent. moisture, as removed from the cells, and only 62 per cent. lead. It was melted without briquetting, giving about one-half the lead as molten metal and the other half was drossed. The melted lead contained 0·83 per cent. copper, 0·02 per cent. iron, 0·15 per cent. zinc, 26·2 oz. silver per ton, and 0·08 oz. gold. Evidently, briquetting of the sponge lead is essential to satisfactory melting.

Batch agitation was practiced, a Pachuca agitator being filled with about 8 tons of brine containing 300 gm. sodium chloride per litre and then enough ore added so that 1 ton of solution was present for each 20 lb. of lead to be dissolved, this being from 1,400 to 2,300 lb. of zinc-plant residue. Agitation was continued for 30 minutes after the addition of all the material. The batch was then transferred to settling tanks by a sand pump and the clear liquor fed direct to the electrolytic cells, of which there were four (old copper-refining cells) placed in cascades of two each, about 9 ft. 6 in. long, 2 ft. 3 in. wide, and 5 ft. deep with a false bottom of canvas to provide agitation by air. Anodes and cathodes were ¼-in. iron plates supported by copper rods. The electrolyte flow was about 2 gallons per minute, for each 1,000 amp. and a yield of lead amounting to 14·74 lb. per kw.-hour energy was obtained while 2·5 lb. lead precipitated during the solution of 1 lb. iron at the anode. Experience showed it best to provide a solution containing about 10 gm. lead per litre, which could be reduced easily to 2 gm. during passage through the cells. Occasional removal of accumulated zinc iron, and sulphates by the addition of lime was advisable.

It had been planned to use enough zinc dust to precipitate all copper and silver at the end of the leaching, and then to smelt the residue in a reverberatory furnace for the production of copper matte. Previously, the residue had been shipped to the lead smelter at Tooele, Utah. The data on brine leaching, followed by matte smelting at Great Falls, showed a saving over shipping to the lead smelter at Tooele, but later the lead smelter at East Helena, Montana, offered such advantageous smelting rates, in order to get this leady material for mixing with other ores, that work on brine leaching was abandoned. The conclusion about brine leaching at Great Falls was that very few difficulties were apparent but that evaporation of wash solution for recovery of salt would probably be necessary; a very low cost of treatment was anticipated.

ELMORE PROCESSES.

F. E. Elmore, of Boxmoor, England, has been engaged in developing numerous brine leaching processes for removing silver and lead from complex sulphide ores, especially having in mind the ore of the Burma Corporation, small testing plants having been operated in London and at the mines in Burma. However, the isolated position of the Burma mines and the type of labour available there seem to discourage the use of chemical processes. Elmore's patents give a fair idea of his various processes. One method proposes dissolving the lead and part of the silver in hot saturated brines, which have been acidified. Hot brines containing acid or ferric or cupric salts have also been used by many other investigators and have been shown to be efficient solvents of lead sulphide but frequently will not attack the sulphide minerals of silver efficiently without also attacking the zinc sulphide.

Another of Elmore's processes involves treatment of the mixed sulphide ore with concentrated sulphuric acid at about 100 deg. C. in order to attack the galena and convert it into lead sulphate, which can later be removed with a brine, together with any silver that yields to such treatment. However, his patents give few details of results obtainable. Fortunately, a few tests on this method were made at the plant of the Butte and Superior Mining Company. When treating the regular concentrate of the mill in a small laboratory test, material containing 55·8 per cent. zinc and 4·1 per cent. lead was heated for 2 hours at 100 deg. C. with 1·84 specific gravity sulphuric acid (94 per cent.). This was then poured off, washed with water, and a hot saturated brine used for removing the lead. The final residue weighed 89·7 per cent. of the original and contained 1·85 per cent. lead and only 52·6 per cent. zinc. While much of the lead was removed, the loss of zinc was regarded as prejudicial to the process. A sample of middling from the mill was also tested. It contained 10·9 per cent. lead, 27·1 per cent. zinc, 19·1 per cent. iron, and 16·6 oz. of silver per ton before treatment. After treatment, it had lost 22 per cent. in weight, contained 20·6 per cent. zinc, 1·80 per cent. lead, 23·1 per cent. iron, and 20·6 oz. silver per ton. Again, too much of the zinc was attacked.

The Christensen processes resemble the Elmore processes very much except that most of Christensen's proposals involve the use of sulphuric acid in varying concentrations and heating until the zinc sulphide is also converted to zinc sulphate, which is soluble in strong sulphuric acid and can be recovered from it. Brine leaching of the lead and silver from the decomposed residue is then possible. The Anaconda Copper Company also carried out experiments on "fuming" mixed sulphide ore with sulphuric acid and found it possible to decompose it completely so that the zinc could be leached out separately, followed by brine leaching of the lead and silver; but it decided against the method on account of mechanical and other difficulties. If complete decomposition of the ore is carried out in place of the partial sulphating attempted in some of the foregoing processes, the principal advantage is the possibility of practically a complete recovery of the valuable metals.

AMALGAMATED ZINC (DE BAVAY'S), LIMITED, PROCESSES.

This Australian company has been developing what seems like one of the most practical of the numerous schemes proposed for removing lead and silver from zinc-sulphide concentrate without having to decompose the zinc sulphide. The ore is mixed with sufficient zinc chloride to supply 33 per cent. excess chlorine over that necessary for combining with the lead, silver, arsenic, antimony, and tin in the ore and heated to 400 deg. C. to 500 deg. C. with agitation out of contact with air, presumably in a muffle. Under these conditions, the zinc chloride exchanges its chlorine with the other metals present. Chlorides of arsenic, antimony, and tin are volatilised and chlorides of lead and silver are formed but remain in the anhydrous mass. It is then cooled and washed with acidulated water to remove excess zinc chloride, followed by brines to dissolve the lead and silver. Because of the tendency of silver to reprecipitate on zinc sulphide, it is necessary to use a brine containing hydrochloric acid, ferric chloride, or cupric chloride, preferably ferric chloride, and to give this solution a minimum time of contact with the ore. The silver can be removed by a cold brine saturated with lead chloride and containing ferric chloride before the lead is removed by a barren hot brine. A cold solution is used for this purpose in order to minimise the action between zinc-sulphide particles and the ferric chloride in solution. One of the patents of Harry Hey gives details of some of the tests made by this company. A series of 66 charges of ore, totalling about 9 tons of Broken Hill zinc concentrate, was chloridised by the above method and then treated in a leaching vat about 3 ft. deep with the following series of leaching solutions, applied so that they went at once through the charge and did not soak:

(1) For each 300 lb. batch of ore, 10 gallons water with 0·013 lb. HCl per gallon (1·3 gm. per litre) to remove excess zinc chloride. (2) 60 gallons cold brine (24 per cent. NaCl) containing lead chloride and 0·03 lb. HCl per gallon to remove silver (as chloride). (3) 60 gallons neutral brine (24 per cent.) at 90 deg. C. to remove lead (as chloride). (4) 10 gallons of water to recover salt.

The original ore contained 6 per cent. lead, 48 per cent. zinc, and 7·7 oz. silver per ton. The final residue contained 0·21 per cent. lead, 52 per cent. zinc, and 0·7 oz. silver. This is probably one of the most promising and practical of the more recently designed applications of brine leaching of lead.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

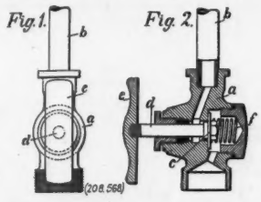
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AGRICULTURAL APPLIANCES.

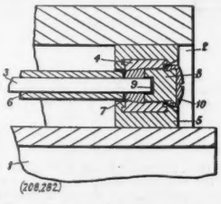
208,568. N. Talliby, West Bromwich. Horticultural and Agricultural Spraying Apparatus. (2 *Figs.*) April 12, 1923.—In horticultural, agricultural and like spraying apparatus, the nozzle or "lance" secured at one end of a flexible delivery pipe, is usually fitted with a cock. The body *a* of the cock to which the delivery pipe and the nozzle or lance *b* are secured, contains a valve *c* which is movable in a direction at right angles to the axis of the nozzle. At the outer projecting end of the valve



stem *d* a pressure or finger piece *e* is provided. According to the invention, this piece is made to extend beyond both sides of the stem, and the construction and arrangement of the body and fingerpiece is such that the whole can be grasped and manipulated by the hand that holds the nozzle, the palm of the hand bearing against one side of the body and a pair of fingers on the outer side of the finger piece. A spring *f* contained within the body serves to move the valve and retain it on its seating. (*Accepted December* 31, 1923.)

ELECTRICAL APPARATUS.

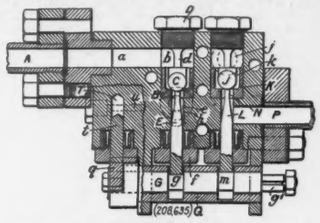
208,282. L. J. Hancock, Wallington, and T. R. Hancock, Wallington. Electric Furnaces. (2 *Figs.*) October 6, 1922.—The invention relates to electric resistance furnaces in which the resistance elements are constituted by a number of rods mounted in supports which are relatively fixed. The furnace consists essentially of a muffle tube 1 surrounded by an outer tube 2, both of refractory material, the rods 3 being mounted in the annular space between the tubes and connected together by arc-shape blocks, one of which is shown in section at 4. The muffle tube 1 is spaced from the outer tube by cement filling 5 in which the blocks 4 are embedded, and in furnaces as hitherto constructed it has been usual to fix the rods 3 in the blocks 4 by means of cement, so that if it be necessary to remove a rod the cement 5 has to be broken away in order that the block 4 may be taken out. According to the present construction, any of the



rods 3 may be removed without disturbing the blocks 4 or cement 5. In order to effect this, the blocks 4 are bored with an aperture slightly larger in diameter than that of the rod 3 or of its protective coating 6. The aperture in the block 4 is formed with a tapered seating to accommodate wedges or preferably a cone 7, this cone being bored to an internal diameter such as to fit over the rod 3 and preferably being slit longitudinally at one or more places. In order to force the wedges or cone into such position as to grip the rod radially, the outer end of the aperture in the block 4 is threaded and fitted with a screw 8, having a recess 9, so that it does not bear on the rod 3 but only on the cone 7 in such a manner as when screwed home to force the wedges or cone into contact with the rod and the tapered seating on the block 4, thus securing an efficient electrical contact whilst permitting longitudinal expansion of the rod due to heat. (*Accepted December* 28, 1923.)

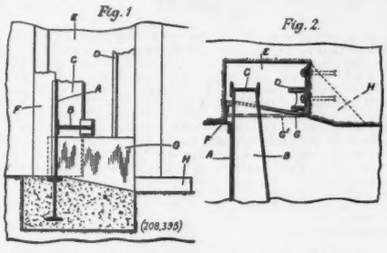
HYDRAULIC MACHINERY.

208,635. H. G. Taylor, Penn, near Wolverhampton, and A. P. Smith, Wolverhampton. Hydraulic Press. (3 *Figs.*) December 15, 1922.—The invention relates more especially to the automatic control of the pressure applied to a hydraulic press. A is an inlet pipe by which oil is delivered to the valve unit. From the pipe A the oil passes by a passage *a* to a chamber *b* into which is screwed a cup B having a seating for a ball valve C. D is a screwed cap closing in the upper end of the cup B and provided with a stalk *d* to limit the upward movement of the valve C. E is a pusher rod which passes up into a chamber *e* through a stuffing box *f*, and this pusher rod is lifted through the agency of a cam *g* on a shaft G which is operated by means of a lever attached to the shaft at *g*1. The raising of the pusher rod E through the medium of its cam lifts the ball C from its seat and allows the oil to pass down into the chamber *e*, and from thence it passes to the ram cylinder by a slanting passage *h*. The exhaust from the ram cylinder passes by means of a passage *j* to a valve chamber *k* containing a ball valve J seated within a cup K similar in all respects to the cup B. L is a pusher rod lifted through the agency of a cam *m* on the shaft G. Beneath the valve J is a chamber connecting with an outlet pipe P. The shaft G is mounted to turn within an eccentrically mounted housing Q to which is keyed a lever *q* constantly pressed in an upward direction by means of a tension spring. T is a small plunger cylinder containing a plunger *t* adapted to bear at its lower end against the lever *q*. The plunger cylinder T communicates with the chamber *e* by means of a passage *u*. When, therefore, the pressure in the ram cylinder reaches a predetermined value, the plunger *t* acting against the pressure of the spring depresses the lever *q* and turns the housing Q sufficiently



to move the shaft G bodily downwards a distance which allows of the pusher rod E moving down sufficiently to permit the ball C to re-seat and cut off the oil supply, notwithstanding that the operating lever of the shaft G is in the open position. As the cam *m* has considerably more throw than the cam *g* it can be arranged that the turning of the shaft to bring the cam *m* to the operative position will always have the effect of pressing up the pusher rod L and lifting the exhaust valve J, whatever the angular position of the lever *q* may be. (*Accepted December* 31, 1923.)

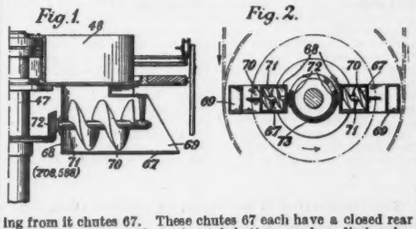
208,395. Ransomes and Rapier, Limited, London, and Sir F. W. S. Stokes, K.B.E., London. Sluice Gates. (4 *Figs.*) January 3, 1923.—The invention relates to sluice gates of the vertically sliding type in which the guides for the gate are mounted within lateral recesses in the wall of the channel. The sluice gate comprises a skin plate A supported by girders, of which only the bottom girder B is shown. These supporting girders are all connected at their ends to vertical girders C which carry rollers (not shown) engaging with vertical guides D mounted on the downstream sides of lateral recesses E in the walls of the channel. Across the lower portion of the opening into each recess is disposed a deflecting plate G which extends from the floor of the recess up to as great a height as the bottom girder will permit. This deflecting plate will thus prevent stones



and like obstructions, which may be carried along the bottom of the stream, from passing into the recess and interfering with the movement of the gate and the rollers. The plate will also exclude from the recess the heavy silt carried along the bottom of the stream, but a passage H is provided at the bottom of the recess to allow such silt or stones as may enter the recess over the top of the deflecting plate, or any matter which may be dropped into the recess from above, to be washed out from the recess back into the stream on the downstream side of the gate. The deflecting plate G preferably extends from the downstream edge of the recess at an angle to the wall of the channel and is attached to the member F which is mounted at the upstream corner of the recess, but this plate may, if desired, be disposed straight across the opening into the recess as shown at G1 in chain line in Fig. 2, or to the corner of the member F. (*Accepted December* 28, 1923.)

LIFTING AND HAULING APPLIANCES.

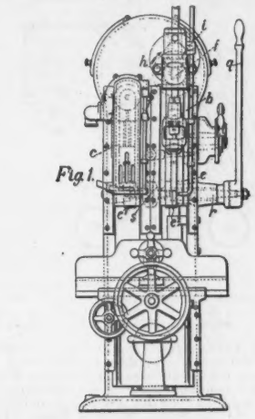
208,588. H. Holt, Walthamstow. Ropeway Bucket Conveyor Systems. (5 *Figs.*) September 19, 1922.—The invention is for improvements in or relating to ropeway bucket conveyor systems in which an automatic bucket-charging device charges the buckets in turn through one or more chutes while moving circularly with the buckets. The primary feature of the invention consists in the combination with the chute which delivers the material from the bucket-charging device, of positive feeding means for ensuring the travel of the material through the chute. These positive feeding means are more particularly necessary with wet fine material such as coal dust or sand which are apt to clog the chutes and not pass freely there-through if under the influence only of gravity. The central pedestal 47 supports an annular hopper 48 having depend-

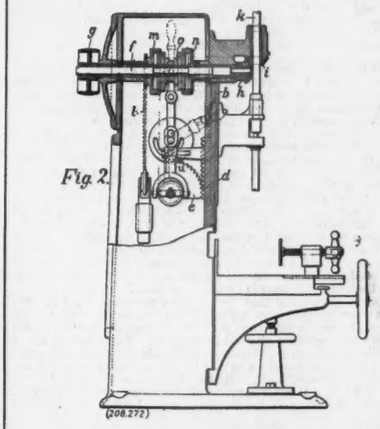


ing from it chutes 67. These chutes 67 each have a closed rear wall 68, a substantially horizontal bottom, and a discharging end 69. Within the chute 67 there is mounted a feeding screw 70, the spindle 71 of which carries a bevel wheel 72. The wheels 72 mesh with a semi-circular rack 73 carried upon the pedestal 47 and are thus alternately rotated during half of each rotation of the chutes 67 around the pedestal 47. The period of rotation of the screw will be that during which a bucket is being filled from its chute. During the remaining half of each rotation of the bucket-charging device the screw will remain stationary, and if the exterior of the screw is made a fairly close fit in the chute 67 it will operate to seal the latter. The pitch and other dimensions of the screw will, of course, be of such proportions as to deliver a suitable quantity of material through the chute during the period of the screw's rotation, and obviously the semi-circular rack 73 will be so positioned as only to rotate the screw when the bucket-charging device is rotating with a bucket under the chute in charging position. (*Accepted December* 31, 1923.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

208,272. Thomas White and Sons, Limited, Paisley, and R. Anderson, Paisley. Morticing Machines. (3 *Figs.*) October 2, 1922.—The invention relates to combined chain cutter and hollow chisel morticing machines of the type comprising a chain cutter and a hollow chisel morticing tool arranged to be movable as, for example, by means of slides when it is desired to bring such tools separately into operation. The machine framework *a* carries the hollow chisel morticing tool and chain-cutter slides or heads *b*, *c*, which are moved by racks *d* and pinions *e* controlled from a single control lever. The power shaft *f* has a single driving pulley *g* and loosely mounted upon sleeves on such shaft connected with clutch elements is a bevel wheel *h* for driving a corresponding bevel *i* upon the

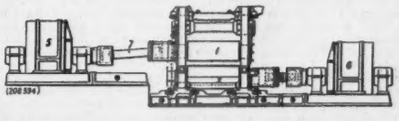




hollow chisel morticing tool spindle *k* and also a chain drive *l* for the chain cutter. In conjunction with such power transmission means clutch elements *m*, *n* are provided adapted to co-operate with a central clutch member *o* upon the power shaft so that either of such power transmitting means may be connected to the power shaft as required. The movement of the tool heads or slides for bringing the tools into operative position is effected by a single control lever *q* mounted upon a control shaft *r* on which are arranged the pinions *s* effecting the movement of the tool heads or slides, such pinions being associated with clutch members *s*1, *s*2 co-operating with an intermediate clutch *s* which is mounted upon the shaft of the control lever. (*Accepted December* 28, 1923.)

MINING, METALLURGY AND METAL WORKING.

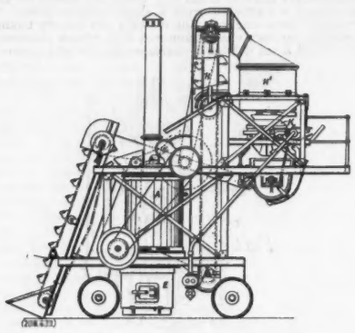
208,594. The English Electric Company, Limited, London, L. Rothera, London, H. S. Carnegie, London, and J. C. Wilson, London. Rolling Mills. (3 *Figs.*) September 20, 1922.—The invention relates to electrically-driven rolling mills of the type in which the mill comprises a pair of superposed main rolls each of which is positively driven and which have their axes horizontal and parallel with each other. In accordance with the invention, each of the two main rolls 1,



2 is driven by a separate fixed motor 5, 6 without positive determination of the speed relation of the rolls during the rolling periods. The motor 5 drives the upper roll 1 through the spindle 7, and the motor 6 drives the bottom roll 2 through its spindle 8. The arrangement of these spindles 7 and 8 provides for vertical movements of the rolls relative to the members by which they are driven, which is necessary in obtaining the adjustment of the distance between the roll centres. (*Accepted* December 31, 1923.)

208,623. Sir W. G. Armstrong, Whitworth and Co., Limited, Manchester, J. M. Jackson, Manchester, and H. O. Jones, Manchester. Drying Ores. (3 *Figs.*) November 9, 1922.—The invention relates to apparatus for drying ores,

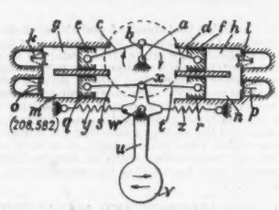
slags, limestone, clinker, sand and other road-making materials and mixing the dried material with tar or other binder, of the type in which a drying drum with a furnace below receives the material from a hopper and an enclosed conveyor transfers the dried material to a storage bin, weighing apparatus and mixer, and in which an elevator conveys the material to the drying drum and a pump raises tar or bitumen to a measuring apparatus which delivers a desired quantity thereof to the mixer. The invention consists in the particular construction, combination and disposition of the apparatus comprising a vertical cylindrical vessel A closed top and bottom, mounted on a central vertical shaft adapted to be oscillated to and fro thereon and fitted internally with a number of helically disposed discs or plates joined



together to form a continuous spiral path from top to bottom of the vessel, a furnace K placed below the vessel A, the hot gases and products of combustion from which pass upwards therethrough, means by which a rapid backwards and forwards rotary or circumferential shaking motion is imparted to the vessel A to cause the material to traverse slowly from top to bottom, an enclosed elevator H to convey the dried material away, a storage hopper H1 fitted with a discharge gate to receive the dried material, a weighing machine K placed below the storage hopper, a mixing chamber of the revolving paddle type and a measuring vessel adjacent to the mixing chamber from which a predetermined quantity of binding material (tar or bitumen) is delivered to the mixing chamber. (*Accepted December* 31, 1923.)

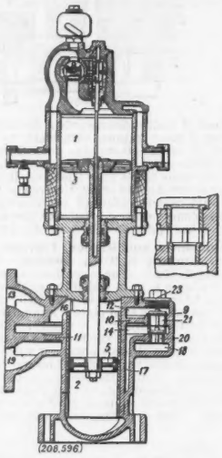
PUMPS.

208,582. G. Constantinesco, Weybridge, Surrey. Pumps. (6 *Figs.*) September 16, 1922.—The invention has for its object to construct a pump which will give a variable alternating or continuous flow of liquid with the pump piston having a constant displacement. The invention consists in a pump comprising a double acting piston working in a cylinder, or two independent pistons working in two separate cylinders, the cranks driving the pistons being in suitable relative phase apart, while the cylinders are arranged so that they are caused to oscillate an inertia device. The driving shaft *a* carries a crank *b* connected by the connecting-rods *c*, *d* to opposed pistons *e*, *f* working in co-axial cylinders *g*, *h*, suction valves *k*, *l* being provided in the ends of the cylinders. The ends of the cylinders are in communication with parallel cylinders *n*, *m* having delivery valves *o*, *p* at their ends. Opposed pistons *q*, *r* are provided in these cylinders connected by rods *s*, *t* with a lever *u* carrying a mass *v* and pivoted at a fixed pivot *w*. Springs *y*, *z* are provided tending to keep the swinging mass in its mean position. The operation is as follows. Supposing that the suction valves *k*, *l* are in permanent communication with a liquid tank under given constant pressure, the pump cylinders *g*, *h*, *m*, *n* being filled with liquid together with the other pipes in the system. Then for any given oscillation of the pump pistons *e*, *f*, the liquid will transmit movement to the lever *u* and mass *v*. Since the liquid columns are relatively short, the liquid will practically operate as a flexible connecting rod. If the frequency of the pump piston increases, the inertia of the mass *v* will oppose considerable reactance to



the motion and considerable pressures will be generated in the pump cylinders. When there is no delivery from the pump these pressures will be greater or less according to the speed of the pump pistons *e*, *f*, but the displacements of the point of connection *x* to the inertia device will always be the same as the displacement of the pump pistons *e*, *f*. When the pump is delivering liquid the pressures diminish and the displacement of the inertia will be less than that of the pump pistons *e*, *f*. At each suction stroke of the pump piston a fall of pressure will take place on the corresponding side of the piston. The inertia device, however, will not be able to follow the liquid column immediately, and thus the suction valve on that side will open and liquid will enter the cylinder. On the pressure stroke of the pump piston, the pressure generated will not be able to move the inertia device immediately, and some liquid will, therefore, be discharged through the delivery valve, if the back pressure is not higher than the pump pressure. If the back pressure rises to a certain limit the delivery valve will not open and the inertia device will then simply be kept swinging to and fro, with its maximum stroke, the motion going on without any absorption of power by the prime mover driving the pump except to overcome friction. When, however, the back pressure diminishes, for example, by utilising the liquid, the delivery valve will again open and work will be done by the prime mover depending on the amount of flow. It will be seen that the maximum pressure obtained at the delivery valves for constant flow is a function of the frequency of the pump and, therefore, by speeding up or slowing down the prime mover, different maximum pressures may be obtained for the same flow. It is obvious that this pump produces pressures even when there is no flow and this property enables it to be used as a governor by allowing such pressure to act on a suitable servo-motor; the pressure risingas the square of the speed. (*Accepted December* 31, 1923.)

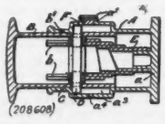
208,596. G. D. Peters and Co., Limited, Westminster, London, and Slough, and W. H. Holey, Slough. Pumps. (7 *Figs.*) September 21, 1922.—The invention has reference to double-acting pumps of the kind in which the suction and delivery valves are arranged in a laterally extending valve chest formed in one with the pump barrel, the valve chest comprising a common chamber divided into two compartments, one in free communication with one end of the pump barrel and the other in free communication with the other end of the pump barrel, each compartment having valve-controlled parts whereby it is placed alternately in communication with a chamber of the housing or valve chest in free communication with the suction branch, and with another chamber of the housing or valve chest in free communication with the delivery branch. The pump comprises a steam cylinder 1 in line with the pump cylinder 2, the piston 3 of the steamcylinder being directly connected to the piston 5 of



the pump cylinder 2. Extending circumferentially of the pump cylinder 2 is a valve chest 9 divided by horizontal partitions 10, 11 into three part annular chambers, namely, a delivery chamber 12 in free communication with the delivery branch 13; an intermediate chamber 14 divided by a vertical web into two parts, one in communication, through passages 16, with the upper end of the pump cylinder and the other in communication with the lower end of the pump cylinder through passages 17; and a suction chamber 18 in free communication with the suction branch 19. Communication between the chambers 18, 14 is controlled by a number of suction valves 20 arranged in a part-annular row below a similarly arranged corresponding number of delivery valves 21 controlling communication between the chambers 14, 12. Located above each pair of valves 20, 21 is a cap 23 removably screwed into the top wall of the valve chest. (*Accepted December* 31, 1923.)

RAILWAYS AND TRAMWAYS.

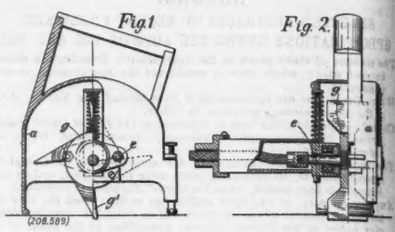
208,608 J. Mitchell, Putney, London, and J. C. G. Cossey, Golders Green, London. Buffers. (11 *Figs.*) October 4, 1922.—The invention relates to self-contained buffers for railway vehicles in which, after a plunger consisting of a tube closed only by the buffer head has been inserted in the casing from the front end, locking plates or bars free to move axially in recesses provided in the casing are inserted through slots provided in the casing and plunger. According to the invention, the rear end plate is integral with the casing while the plunger can still be inserted from the front end of the casing. A is the casing, the back end *a* of which is integral with the body of the casing. The plunger B is provided with internal ribs or projections *b* which form abutments for a hollow disc shaped member C. A locking plate D is inserted into the member C, and for this purpose an aperture *a*1 is provided in the casing A and an aperture *b*1 coaxial with the disc C in the plunger B. A spring E is inserted in



the rear end of the plunger B, the disc C forming an abutment for the front end of the spring and the back end *a* of the casing its rear abutment. A tubular inward extension of the end *a* of the casing maintains the spring in the central position. Oppositely disposed recesses *a*3 provided by an enlargement of the external surface of the casing form a guide for the locking plate D. After the insertion of the locking plate the aperture *a*1 is closed by a filling piece F which is secured to the casing. A small hole *a*4 is shown opposite the hole *a*1 by which the locking plate may, on the removal of the filling piece, be pushed out of the plunger and casing. In order to insert the locking plate, the spring E is slightly compressed until the hollow disc C is in line with the aperture *a*1 in the casing. Under the buffing shocks the locking plate moves in the recesses *a*3 of the casing until it encounters the closed ends of the recesses. (*Accepted December* 31, 1923.)

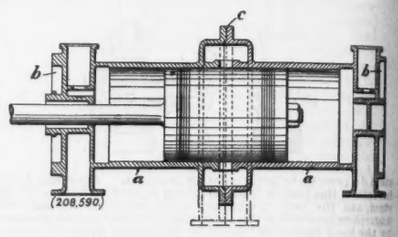
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

208,589. W. B. Wright, Bootle, Liverpool. Scaling, Chipping or Brushing Surfaces. (6 *Figs.*) September 19, 1922.—The invention has for its object to provide a light, compact and portable machine adapted for cleaning, scaling, chipping or brushing surfaces. The improved apparatus forming the subject matter of the invention comprises a rotary shaft *e* adapted to receive and drive a rotary member *g* having projections *g*1 adapted to act directly upon a surface under treatment, a casing *a* within which the rotary member is mounted, the casing having guide means in which the bearings of the shaft *e* aresupported in a manner allowing sliding movement of the shaft towards and away from the surface operated upon. The projections *g*1 take the form of chipping, scaling or brushing tools, and project slightly from an open mouth in the casing, which when the apparatus is in use is turned towards the surface being treated. Where fluted, corrugated or other hollow or irregular surfaces have to be dealt with, a rotary member having



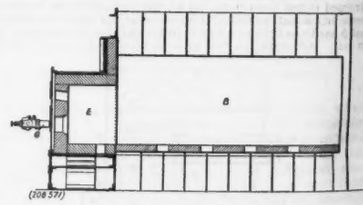
striker projections is provided to actuate a rapidly reciprocating chipping or like tool mounted in a guideway in the casing. (*Accepted December* 31, 1923.)

208,590. H. Bentley, Bolton. Steam Engines. (1 *Fig.*) September 19, 1922.—The invention relates to steam engines of the central exhaust or uniflow type having the exhaust belt formed in one with the cylinder. According to the invention, the cylinder is formed in only two parts *a*, each having cast integral with it one cylinder head *b*, which parts are connected by a flanged joint *c* at or in the region of the exhaust belt where the cylinder is coolest and the liability to heat losses by conduction and radiation least. Notwithstanding that the cylinder com-



prises only two parts, it is a simple operation to bore the parts so that the cylinder is of a "barrel" form, that is, of gradually increasing diameter from each end towards the middle of its length, where it is of greatest diameter as is required in the uniflow type of engine. If desired, a renewable liner may be fitted to an engine cylinder constructed in accordance with the invention and such liner may be in one piece extending the full length of the cylinder, or in two pieces jointed at the middle of the length of the cylinder. (*Accepted December* 31, 1923.)

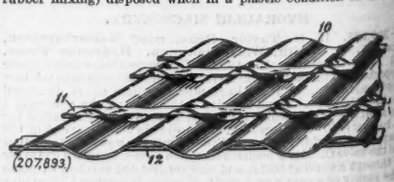
208,571. J. J. Kermode, Liverpool. Sectional Steam Generators and Water Heaters. (3 *Figs.*) August 12, 1922.—This invention relates to boilers, water-heaters and the like adapted to burn liquid fuel, and has reference more particularly to boilers or heaters of the sectional type, such, for example, as are used for heating buildings by steam or hot water. Accord-



ing to the invention, the usual front section of a sectional boiler is dispensed with, and there is fitted to the front of the main furnace a supplementary furnce E, which forms an extension of the main furnace B, and which is fitted with a liquid fuel burner or burners G, the air supplied to the supplementary furnace and the main furnace being independently controlled. (*Accepted December* 31, 1923.)

MISCELLANEOUS.

207,893. R. H. Rogers, London, and T. Perry, New Lenton, Nottingham. Concrete Roofs and Partitions. (2 *Figs.*) November 9, 1922.—The invention relates to concrete roofs and partitions. According to the invention, there is provided a construction of concrete roof and partition comprising a corrugated metal sheet 10, a series of sheet-metal reinforcing strips 11, 12 disposed transverse to the corrugations on one or both sides of the metal sheet 10 and attached thereto by spot welding, and a layer of hard setting material 13 (*e.g.*, concrete or rubber mixing) disposed when in a plastic condition on one or



both sides of the metal sheet in such quantities as to fill up the valleys between the corrugations and cover the reinforcing strips. The reinforcing strips may have one or both edges bent out of the normal plane of the strip for the purpose of gripping and binding the cement. In a preferred construction, one or both edges of the metal strip are bent out of the normal plane of the strip towards the metal sheet where they bridge the valleys between the corrugations and away from the sheet where they cross the crests of the corrugations. (*Accepted December* 19, 1923.)